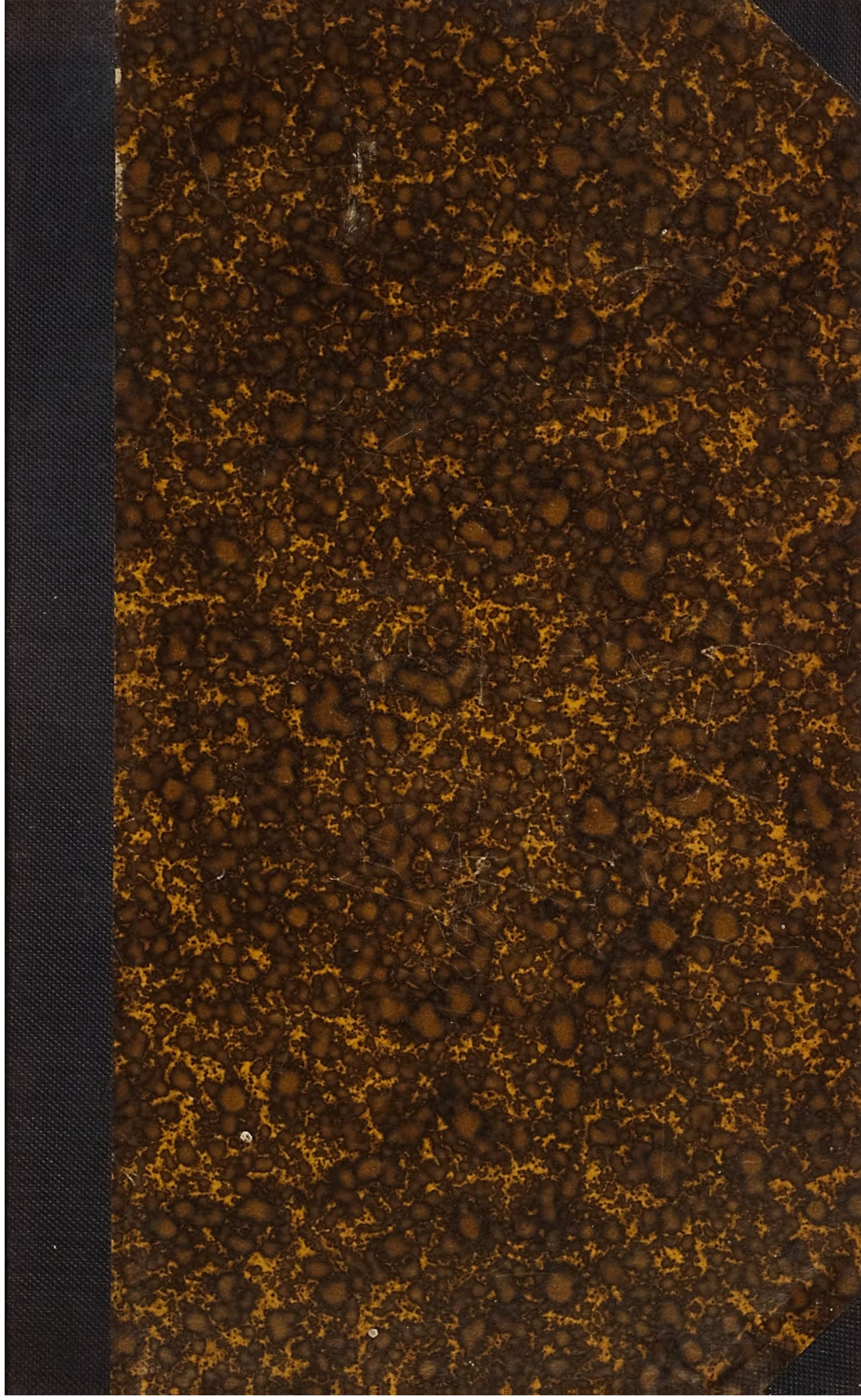




Oecon.

Bulletin

362 gh

U. S. DEPARTMENT OF AGRICULTURE
OFFICE OF EXPERIMENT STATIONS

BULLETIN No. 16

PROCEEDINGS
OF THE
SIXTH ANNUAL CONVENTION
OF THE ASSOCIATION OF
American Agricultural Colleges and Experiment Stations

HELD AT
NEW ORLEANS, LOUISIANA

NOVEMBER 15-19, 1892

EDITED BY
A. W. HARRIS, for the Office of Experiment Stations
AND
H. E. ALVORD, for the Executive Committee of the Association

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE

WASHINGTON
GOVERNMENT PRINTING OFFICE
1893



OFFICE OF EXPERIMENT STATIONS.

- A. W. HARRIS, Director.
 A. C. TRUE, Assistant Director and Editor of departments of Botany, Field Crops and Horticulture.
 W. O. ATWATER, Special Editor for Foreign Work.
 E. W. ALLEN, Editor of departments of Chemistry, Foods and Animal Production, and Dairying.
 W. H. BEAL, Editor of departments of Fertilizers, Soils, and Indexes.
 WALTER H. EVANS, Editor of departments of Seeds, Weeds, and Diseases of Plants.
 S. L. SOMMERS, Librarian and Record Clerk.

THE AGRICULTURAL EXPERIMENT STATIONS.

- | | |
|---|--|
| <p>ALABAMA—<i>Auburn</i>: College Station; W. L. Broun.† <i>Uniontown</i>: Canebroke Station; B. M. Duggar. ‡
 ARIZONA—<i>Tucson</i>: F. A. Gulley.*
 ARKANSAS—<i>Fayetteville</i>: R. L. Bennett.*
 CALIFORNIA—<i>Berkeley</i>: E. W. Hilgard.*
 COLORADO—<i>Fort Collins</i>: Alston Ellis.*
 CONNECTICUT—<i>New Haven</i>: State Station; S. W. Johnson.* <i>Storrs</i>: Storrs School Station; W. O. Atwater.*
 DELAWARE—<i>Newark</i>: A. T. Neale.*
 FLORIDA—<i>Lake City</i>: O. Clute.*
 GEORGIA—<i>Experiment</i>: R. J. Redding.*
 IDAHO—<i>Moscow</i>: C. P. Fox.*
 ILLINOIS—<i>Champaign</i>: G. E. Morrow.†
 INDIANA—<i>Lafayette</i>: C. S. Plumb.*
 IOWA—<i>Ames</i>: James Wilson.*
 KANSAS—<i>Manhattan</i>: G. T. Fairchild.
 KENTUCKY—<i>Lexington</i>: M. A. Scovell.*
 LOUISIANA—<i>Audubon Park, New Orleans</i>: Sugar Station. <i>Baton Rouge</i>: State Station. <i>Calhoun</i>: North Louisiana Station; W. C. Stubbs.*
 MAINE—<i>Orono</i>: W. H. Jordan.*
 MARYLAND—<i>College Park</i>: R. H. Miller.*
 MASSACHUSETTS—<i>Amherst</i>: State Station; C. A. Goessmann.* <i>Amherst</i>: Hatch Station; H. H. Goodell.*
 MICHIGAN—<i>Agricultural College</i>: L. G. Gorton.*
 MINNESOTA—<i>St. Anthony Park</i>: C. D. Smith.*
 MISSISSIPPI—<i>Agricultural College</i>: S. M. Tracy.*</p> | <p>MISSOURI—<i>Columbia</i>: E. D. Porter.*
 NEBRASKA—<i>Lincoln</i>: C. L. Ingersoll.*
 NEVADA—<i>Reno</i>: S. A. Jones.*
 NEW HAMPSHIRE—<i>Durham</i>: G. H. Whitcher.*
 NEW JERSEY—<i>New Brunswick</i>: State Station; E. B. Voorhees.* <i>New Brunswick</i>: College Station; A. Scott.*
 NEW MEXICO—<i>Las Cruces</i>: H. Hadley.*
 NEW YORK—<i>Geneva</i>: State Station; P. Collier.* <i>Ithaca</i>: Cornell University Station; I. P. Roberts.*
 NORTH CAROLINA—<i>Raleigh</i>: H. B. Battle.*
 NORTH DAKOTA—<i>Fargo</i>: J. B. Power.*
 OHIO—<i>Wooster</i>: C. E. Thorne.*
 OKLAHOMA—<i>Stillwater</i>: J. C. Neal.*
 OREGON—<i>Corvallis</i>: J. M. Bloss.*
 PENNSYLVANIA—<i>State College</i>: H. P. Armsby.*
 RHODE ISLAND—<i>Kingston</i>: C. O. Flagg.*
 SOUTH CAROLINA—<i>Fort Hill</i>: J. S. Newman.
 SOUTH DAKOTA—<i>Brookings</i>: L. McLouth.
 TENNESSEE—<i>Knoxville</i>: C. F. Vanderford.*
 TEXAS—<i>College Station</i>: J. H. Connell.*
 UTAH—<i>Logan</i>: J. W. Sanborn.*
 VERMONT—<i>Burlington</i>: J. L. Hills.*
 VIRGINIA—<i>Blacksburg</i>: J. M. McBryde.*
 WASHINGTON—<i>Pullman</i>: J. W. Heston.*
 WEST VIRGINIA—<i>Morgantown</i>: J. A. Myers.*
 WISCONSIN—<i>Madison</i>: W. A. Henry.*
 WYOMING—<i>Laramie</i>: A. A. Johnson. </p> |
|---|--|

* Director.

† President of board of direction.

‡ Assistant director in charge.

§ Acting director.

|| Chairman of council.

CONTENTS.

	Page.
Letter of transmittal.....	6
Constitution of the Association of American Agricultural Colleges and Experiment Stations.....	7
Officers of the association	11
List of delegates in attendance	13
Call for the convention.....	16
Programs	17
Proceedings:	
Report of the executive committee	21
Report of the Section on College Work	24
Report of the Section on Agriculture	28
Report of the Section on Botany.....	33
Report of the Section on Chemistry.....	36
Report of the Section on Entomology.....	41
Annual address of President.....	58
The relation of technical to general courses of study. By D. G. Fairchild ..	67
The treatment of apple scab. By E. S. Goff	87
A comparative test of fungicides in checking potato blight and rot. By L.R. Jones.....	89
A study of fruit decays. By B. D. Halsted	91
Notes on the breeding of fruits. By N. E. Hansen.....	92
The crossing of cucurbits. By L. H. Pammel.....	94
Report of committee on the coöperative station exhibit at the World's Columbian Exposition	99
Report of the committee on the collective college exhibit at the World's Columbian Exposition	103
Report of committee on World's Agricultural Congress	104
Report of committee on coöperation with the Weather Bureau	106
The relation of the agricultural and mechanical colleges to the Department of the Interior	114
Appendix:	
The Section on Agriculture and Chemistry	129
Grass gardens—methods and purposes. By W. M. Hays	130
Advances in agricultural education. By W. M. Hays.....	132
The bulletin—present and prospective. By C. L. Ingersoll	138
What shall the professor of agriculture teach? By P. M. Harwood	139
Methods of irrigation. By L. G. Carpenter	142
Forage plants for the semiarid West. By C. C. Georgeson.....	145
The establishment of official methods of experimentation. By F. A. Gulley.....	147
What is the live weight of an animal? By H. J. Patterson	150
Physical tests of soils. By R. H. Loughridge	156
Suggested experiments in breeding. By William H. Brewer.....	162
The Section on Horticulture.....	167
The Section on Botany.....	168

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., August 15, 1893.

SIR: I have the honor to transmit herewith for publication Bulletin No. 16 of this Office, containing the proceedings of the sixth annual convention of the Association of American Agricultural Colleges and Experiment Stations, held at New Orleans, La., November 15-19, 1892. The stenographic report of this meeting was made by Mr. S. E. Black, of this Office.

Respectfully,

A. W. HARRIS,
Director.

Hon. J. STERLING MORTON,
Secretary of Agriculture.

CONSTITUTION

OF THE

ASSOCIATION OF AMERICAN AGRICULTURAL COLLEGES AND EXPERIMENT STATIONS.

NAME.

This Association shall be called The Association of American Agricultural Colleges and Experiment Stations.

OBJECT.

The object of this Association shall be the consideration and discussion of all questions pertaining to the successful progress and administration of the colleges and stations included in the Association, and to secure to that end mutual coöperation.

MEMBERSHIP.

(1) Every college established under the act of Congress approved July 2, 1862, or receiving the benefits of the act of Congress approved August 30, 1890, and every agricultural experiment station established under State or Congressional authority, the Bureau of Education of the Department of the Interior, the Department of Agriculture, and the Office of Experiment Stations of the last-named Department, shall be eligible to membership in this Association.

(2) Any institution a member of the Association in full standing may send any number of delegates to the meetings of the Association, but one shall be designated to the Association as the regular representative and voting delegate. The same delegate may represent both a college and a station, but shall cast only one vote in general sessions. Other delegates may be designated by any institution to represent it in specified sections of the Association, but such delegates shall vote only in such sections, and no institution shall be allowed more than one vote in any sectional meeting.

(3) Delegates from other institutions engaged in educational or experimental work in the interest of agriculture or mechanic arts may, by a majority vote, be admitted to conventions of the Association, with all privileges except the right to vote.

(4) In like manner, any person engaged or directly interested in agriculture or mechanic arts, who shall attend any convention of this Association, may be admitted to similar privileges.

SECTIONS.

(1) The Association shall be organized into sections upon (1) college work; (2) agriculture and chemistry; (3) horticulture and botany; (4) entomology; (5) mechanic arts. The executive committee shall, upon the request of any ten institutions represented in the Association, provide for the organization of provisional sections at any convention.

(2) Each section shall conduct its own proceedings and shall keep record of the same, and present a synopsis thereof to the Association at the close of every convention; and no action of a section, by resolution or otherwise, shall be valid until the same shall have been ratified by the Association in general session.

MEETINGS.

(1) This Association shall hold at least one meeting in every calendar year, to be designated as the annual convention of the Association. Special meetings may be held at other times, upon the call of the executive committee, for purposes to be specified in the call.

(2) The annual convention of the Association shall comprise general sessions and meetings of the sections, and provision shall be made therefor in the program. The section meetings may be simultaneous or otherwise, at the discretion of the executive committee, but at least two sections of the Association, to be designated each year by the executive committee, shall present in general session of each convention a portion of the subjects coming before them.

OFFICERS.

(1) The general officers of this Association shall be a president, five vice-presidents, a bibliographer, and a secretary, who shall also be treasurer. The president, junior ex-president, the secretary, and four persons to be chosen by the Association shall constitute an executive committee, which shall elect its own chairman.

(2) Each section shall, by ballot, nominate to the Association in general session, for its action, a chairman and a secretary for such section.

(3) Officers shall be chosen by ballot at the annual convention of the Association, and shall hold office from the close of the convention at which they are elected until their successors shall be chosen.

(4) Any person being an accredited delegate to an annual meeting of the Association, or an officer of an institution which is a member of the Association in full standing at the time of election, shall be eligible to office.

DUTIES OF OFFICERS.

(1) The officers of the Association shall perform the duties which usually devolve upon their respective offices.

(2) The president shall deliver an address at the annual convention before the Association in general session.

(3) The chairman of each section shall make, at the annual convention, a report to the Association in general session of the progress during the preceding year of the subject or subjects appertaining to his section, and such reports shall not occupy more than twenty minutes each.

(4) The executive committee shall determine the time and place of the annual conventions and other meetings of the Association, and shall, between such conventions and meetings, act for the Association in all matters of business. It shall issue its call for the annual conventions of the Association not less than sixty days before the date on which they are to be held, and for special meetings not less than ten days before such dates. It shall be charged with the general arrangement and conduct of all meetings called by it. It shall designate the two sections to present in general session a portion of the subjects coming before them, and shall give notice thereof to the chairmen of such sections at least ninety days prior to the annual convention. It shall provide a well-prepared order of business and a program of exercises, and shall make a seasonable issue of said program. Said committee may fill any vacancy in an office or committee of the Association occurring after the adjournment of the annual convention, such appointee to serve until the next annual election.

FINANCES.

At every annual convention, the Association, in general session, shall provide for obtaining the funds necessary for its legitimate expenses, and may, by appropriate action, call for contributions upon the several institutions eligible to membership; and no institution shall be entitled to representation or participation in the benefits of the Association unless such institution shall have made the designated contribution for the year previous to that in and for which such question of privilege shall arise, or shall have had said payment remitted by the unanimous vote of the executive committee.

AMENDMENTS.

This constitution may be amended at any regular convention of the Association by a two-thirds vote of the delegates present, if the number constitute a quorum: *Provided*, That notice of any proposed amendment, together with the full text thereof and the name of the mover, shall have been given in the call for the convention. Every such proposition of amendment shall be subject to modification or amendment in the same manner as other propositions, and the final vote on the adoption or rejection shall be taken by yeas and nays of the institutions then and there represented.

RULES OF ORDER.

(1) The executive committee shall be charged with the order of business, subject to special action of the convention, and this committee may report at any time.

(2) All business or topics proposed for discussion and all resolutions submitted for consideration of the convention shall be read and then referred, without debate, to the executive committee, to be assigned positions on the program.

(3) Speakers invited to open discussions shall be entitled to twenty minutes each.

(4) In general discussions the ten-minute rule shall be enforced.

(5) No speaker shall be recognized a second time on any one subject while any delegate who has not spoken thereon desires to do so.

(6) The hours of meeting and adjournment adopted with the general program shall be closely observed, unless changed by a two-thirds vote of delegates present.

(7) The presiding officer shall enforce the parliamentary rules usual in such assemblies and not inconsistent with the foregoing.

OFFICERS OF THE ASSOCIATION.

ELECTED AT WASHINGTON, D. C., AUGUST, 1891.

President,

W. L. BROUN, of Alabama.

Vice-Presidents,

C. W. DABNEY, jr., of Tennessee; H. E. STOCKBRIDGE, of North Dakota;
J. W. NICHOLSON, of Louisiana; F. E. EMERY, of North Carolina;
W. H. JORDAN, of Maine.

Secretary and Treasurer,

M. A. SCOVELL, of Kentucky.

Executive Committee,

The PRESIDENT; the SECRETARY;

H. E. ALVORD, of Maryland; J. A. MYERS, of West Virginia;
H. H. GOODELL, of Massachusetts; W. FREAR, of Pennsylvania;
A. T. NEALE, of Delaware.

Chairmen of Sections,

Agriculture, C. L. INGERSOLL, of Nebraska; College Work, E. M. TURNER, of West Virginia;
Botany, GEO. F. ATKINSON, of Alabama; Entomology, L. BRUNER, of Nebraska;
Chemistry, M. A. SCOVELL, of Kentucky; Horticulture, E. A. POPENOE, of Kansas.

Secretaries of Sections,

Agriculture, T. F. HUNT, of Pennsylvania; College Work, H. E. STOCKBRIDGE, of North Dakota;
Botany, L. H. PAMMEL, of Iowa; Entomology, F. M. WEBSTER, of Ohio;
Chemistry, H. H. HARRINGTON, of Texas; Horticulture, T. L. BRUNK, of Maryland.

ELECTED AT NEW ORLEANS, LA., NOVEMBER, 1892.

President,

W. A. HENRY, of Wisconsin.

Vice-Presidents,

W. C. STUBBS, of Louisiana; J. A. MYERS, of West Virginia;
E. W. HILGARD, of California; A. Q. HOLLADAY, of North Carolina;
J. F. HICKMAN, of Ohio.

Secretary and Treasurer,

M. A. SCOVELL, of Kentucky.

Bibliographer,

S. W. JOHNSON, of Connecticut.

Executive Committee,

The PRESIDENT; the JUNIOR EX-PRESIDENT; the SECRETARY;
 H. E. ALVORD, of the District of Columbia; JAS. NEILSON, of New Jersey;
 H. H. GOODELL, of Massachusetts; C. W. DABNEY, jr., of Tennessee.

Chairmen of Sections,

Agriculture and Chemistry, W. A. HENRY, of Wisconsin;	College Work, C. W. DABNEY, jr., of Tennessee;
Botany and Horticulture, F. LAMSON-SCRIBNER, of Tennessee;	Entomology, L. BRUNER, of Nebraska;
	Mechanic Arts, C. W. HALL, of Minnesota.

Secretaries of Sections,

Agriculture and Chemistry, W. C. LATTA, of Indiana;	College Work, M. C. FERNALD, of Maine;
Botany and Horticulture, E. S. GOFF, of Wisconsin;	Entomology, F. M. WEBSTER, of Ohio;
	Mechanic Arts, F. P. ANDERSON, of Kentucky.

LIST OF DELEGATES AND VISITORS IN ATTENDANCE.

Alabama:

College: W. L. Broun, president; P. H. Mell, professor of natural history and geology.

Station (Auburn): A. J. Bondurant, agriculturist; N. T. Lupton, chemist.

Canebrake Station: J. Huggins, trustee; B. M. Duggar, assistant director.

Arizona:

Station: F. A. Gulley, director.

Arkansas:

College: E. H. Murfee, president.

California:

College: R. H. Loughridge, professor of geology and chemistry.

Colorado:

College: L. G. Carpenter, professor of physics and irrigation engineering.

Station: W. J. Quick, director.

Connecticut:

State Station: S. W. Johnson, director.

Storrs Station: C. D. Woods, vice-director and chemist.

Delaware:

Station: A. T. Neale, director.

Florida:

Station: J. P. De Pass, director.

Georgia:

College: J. B. Hunnicutt, professor of agriculture.

Station: R. J. Redding, director; Gustav Speth, horticulturist.

Illinois:

College: G. E. Morrow, professor of agriculture.

Station: G. W. McCluer, assistant horticulturist.

Indiana:

College: J. H. Smart, president; H. A. Huston, professor of agricultural chemistry.

Station: C. S. Plumb, director.

Iowa:

College: H. Osborn, professor of zoölogy and entomology.

Station: L. H. Pammel, botanist.

Kansas:

College: G. T. Fairchild, president.

Station: C. C. Georgeson, agriculturist.

Kentucky:

College: J. K. Patterson, president.

Station: M. A. Scovell, director.

Louisiana:

College (Baton Rouge): J. W. Nicholson, president; B. B. Ross, professor of chemistry and mineralogy; H. A. Morgan, professor of horticulture and entomology.

Louisiana—Continued.

College (Southern University, New Orleans): H. A. Hill, president; V. L. Roy, professor of chemistry; W. J. Nickerson, principal of music department; J. M. Henry, professor of mathematics, Latin and Greek; H. Jamieson, professor of agriculture.

Station (Audubon Park, New Orleans): W. C. Stubbs, director; T. P. Hutchinson, assistant director; J. T. Crawley, chemist; F. H. Burnette, chemist; R. T. Burwell, machinist; J. N. Roussell, sugar-maker; Lucien Soniat, trustee.

Station (Baton Rouge): D. N. Barrow, assistant director; R. E. Blouin, assistant chemist.

Station (Calhoun): J. G. Lee, assistant director.

Tulane University: W. P. Johnston, president; B. V. B. Dixon, professor of metaphysics; J. H. Dillard, professor of Latin; R. Sharp, professor of English; J. B. Ficklen, professor of history; J. H. Deiler, professor of German; A. Fortier, professor of French; J. L. Cross, professor of mathematics; B. Ayres, professor of physics; J. M. Ordway, professor of applied chemistry; H. B. Orr, professor of biology; W. Woodward, professor of Greek; J. W. Pearce, professor of Anglo-Saxon; C. T. Gill, professor of Greek; W. J. Cooper, professor of mechanical engineering; W. Von Phul, professor of physics; T. T. Hall, mechanic; W. O. Rogers, secretary; A. D. Hurt, assistant secretary; D. S. Anderson, instructor.

Maine:

College: M. C. Fernald, president.

Station: W. M. Munson, horticulturist.

Maryland:

Station: R. H. Miller, director; H. J. Patterson, chemist.

Massachusetts:

College: H. H. Goodell, president.

Michigan:

College: O. Clute, president; I. H. Butterfield, trustee; H. Chamberlain, trustee.

Station: P. M. Harwood, agriculturist.

Minnesota:

College: C. W. Hall, dean.

Mississippi:

College: S. D. Lee, president; T. Butler, professor of veterinary science; A. B. McKay, professor of horticulture.

Station: S. M. Tracy, director; W. L. McGee, assistant director; E. R. Lloyd, agriculturist; H. E. Weed, entomologist.

Alcorn College: J. D. Burrus, professor of agriculture and mathematics.

Station (Ocean Springs): F. S. Earle, superintendent.

Missouri:

College: E. D. Porter, dean.

Nebraska:

College: C. L. Ingersoll, dean.

Nevada:

Station: N. E. Wilson, chemist.

New Jersey:

College: Austin Scott, president; B. D. Halsted, professor of botany.

Station: James Neilson, acting director.

New Hampshire:

Station: G. H. Witcher, director.

New Mexico:

College: H. Hadley, president; W. L. Rynerson, trustee.

New York:*College* : I. P. Roberts, professor of agriculture.*Station* : H. H. Wing, agriculturist.**North Carolina:***College* : A. Q. Holladay, president.*Station* : B. W. Kilgore, assistant chemist.**North Dakota:***College* : W. M. Hays, professor of agriculture.**Ohio:***College* : R. H. Warder, trustee; T. F. Hunt, professor of agriculture.*Station* : C. E. Thorne, director; J. F. Hickman, agriculturist.**Oklahoma:***College* : J. C. Neal, professor of natural science.**Pennsylvania:***College* : G. W. Atherton, president.*Station* : H. P. Armsby, director; W. Frear, vice director and chemist.**Rhode Island:***College* : J. H. Washburn, president.*Station* : C. O. Flagg, director.**South Carolina:***Station* : J. S. Newman, vice director and agriculturist.**Tennessee:***College* : C. W. Dabney, jr., president.*Station* : F. Lamson-Scribner, director and botanist; C. F. Vanderford, assistant director.**Texas:***College* : W. R. Cavitt, trustee.*Station* : G. W. Curtis, director and agriculturist.**Utah:***College* : J. W. Sanborn, president.**Vermont:***Station* : W. W. Cooke, director.**West Virginia:***College* : E. M. Turner, president.*Station* : J. A. Myers, director.**Wisconsin:***College* : E. S. Goff, professor of horticulture and economic entomology; F. H. King, professor of agricultural physics; H. B. Dale, trustee.*Station* : W. A. Henry, director; F. W. Woll, assistant chemist.**Wyoming:***College* : A. A. Johnson, president.**U. S. Department of Agriculture:**

H. W. Wiley, chemist; H. E. Alvord, special agent.

Office of Experiment Stations:

A. W. Harris, director; A. C. True, assistant director; E. W. Allen, editor; S. E. Black, private secretary.

Bureau of Education:

J. W. Holcombe, chief clerk.

Visitors:

Mrs. N. T. Lupton, Mrs. P. H. Mell, Mrs. V. M. Fleming, J. F. Merry, N. S. Dougherty (secretary Louisiana Bureau of Agriculture), J. B. Buchanan (of the New Orleans Academy of Science), W. Murray, J. W. Coleman, Mrs. C. L. Ingersoll, Mrs. J. S. Newman, Mrs. J. A. Myers.

CALL FOR THE CONVENTION.

ASSOCIATION OF AMERICAN AGRICULTURAL
COLLEGES AND EXPERIMENT STATIONS,
OFFICE OF THE EXECUTIVE COMMITTEE,
Washington, D. C., August 1, 1892.

By authority of the executive committee, a delegate convention of this association is hereby called to meet in the city of New Orleans, La., on Tuesday, November 15, 1892, at noon.

The headquarters of the association during this convention will be at the St. Charles Hotel.

The program for the sessions and other particulars will be announced later.

At any regularly called meeting of the association each college established under the act of Congress approved July 2, 1862, and each experiment station established under State or Congressional authority, and the Department of Agriculture shall be entitled to one delegate, but no delegate shall cast more than one vote. Other institutions engaged in experimental work in the interest of agriculture may be admitted to representation in this association by a majority vote at any regular meeting of the association. (Extract from constitution.)

In accordance with the requirements of the constitution, the sections on botany and college work are hereby designated to present a portion of the subjects coming before them in the general sessions of the convention.

The chairmen of the several sections will each be called upon for a report of progress, not to exceed fifteen minutes in the reading, during the first day of general sessions.

Conforming to the action of the Washington convention of 1891 (see Proceedings, p. 61), there will be submitted, in connection with the program for the convention of 1892, such amendments to the constitution of the association as are deemed desirable by the executive committee, and the consideration of this subject will be assigned a place in the program.

For the executive committee:

HENRY E. ALVORD,
Chairman.

PROGRAMS.

PLACES AND HOURS OF MEETING.

All sessions will be held at Tulane University, corner of Common and Baronne streets, two squares from the St. Charles Hotel.

Rooms for the section meetings will be duly designated.

Hours for meetings, 9 a. m., 2 p. m., and 7:30 p. m.

Headquarters for delegates when not in session, St. Charles Hotel, on St. Charles street, between Common and Gravier streets and one square from the canal.

SPECIAL NOTICE.

The chairmen and secretaries of sections are requested to hand to the secretary of the association, well in advance, written announcements to be made on behalf of the sections from day to day; also to preserve such records of the section meetings as will serve for a correct journal of their proceedings.

TUESDAY, NOVEMBER 15, 1892.

10 a. m.—Meeting of the executive committee, at the St. Charles Hotel.

12 m.—General session. Opening exercises and reports of committees.

2 p. m.—General session. Reports from chairmen of the sections.

7:30 p. m.—Meetings of all sections for organization and preliminary business.

8 p. m.—General session. Annual address by the president of the association, William LeRoy Broun, LL. D., president Agricultural and Mechanical College of Alabama.

WEDNESDAY, NOVEMBER 16.

9 a. m.—General session. Miscellaneous business. Report of committee on amendments to the constitution and action thereon.

10 a. m.—Meetings of the sections on agriculture, botany, and entomology; others if desired.

1 p. m.—Visit to the Louisiana Sugar Experiment Station, Audubon Park.

7:30 p. m.—General session. Subjects presented by the section on botany, Prof. G. F. Atkinson, Cornell University, chairman. Discussion of the publication of the stations, to be opened by Director A. W. Harris, of the U. S. Department of Agriculture, and Director W. A. Henry, of Wisconsin.

THURSDAY, NOVEMBER 17.

9 a. m.—General session. Appointment of committees. Resolutions considered. Discussion: The Association and the World's Columbian Exposition, with reports of standing committees and incidental business. Upon adjournment of the general session, meetings of the sections on chemistry, college work, and horticulture.

2 p. m.—Meetings of all the sections.

7:30 p. m.—General session. Consideration of resolutions and general business. Annual election of officers. Reports from sections and action thereon. Subjects

presented by the section on college work, President E. M. Turner, University of West Virginia, chairman. Discussion: The Relations of the Colleges to the Department of the Interior, with an address by John W. Holcombe, chief clerk, Bureau of Education, representing the Department.

FRIDAY, NOVEMBER 18.

Excursion by special train to Baton Rouge, with visits to the State Agricultural and Mechanical College, the State Agricultural Experiment Station, and several sugar plantations and sugarhouses in operation. Complimentary dinner at Baton Rouge.

Section meetings to be announced. Final adjournment.

SECTION ON AGRICULTURE.

C. L. INGERSOLL, of Nebraska, chairman.

T. F. HUNT, of Ohio, secretary.

- (1) Number of animals in a feeding experiment. C. S. Phelps.
- (2) Individual variation in cows. G. W. Curtis.
- (3) What is the live weight of an animal? H. J. Patterson.
- (4) Stock-breeding at experiment stations. W. H. Brewer.
- (5) Breed tests. W. W. Cooke and E. B. Voorhees.
- (6) Mistakes to avoid in dairy experiments. H. H. Wing and W. H. Jordan.
- (7) Mistakes in feeding young animals. I. P. Roberts.
- (8) Technique in agricultural experimentation. J. F. Hickman.
- (9) The establishment of official methods of experimentation. W. A. Henry and F. A. Gulley.
- (10) Testing new varieties prior to their introduction. H. J. Waters.
- (11) Coöperative field experiments. H. B. Battle and F. D. Gardner.
- (12) Grass gardens, methods and purposes. H. P. Armsby and W. M. Hays.
- (13) Forage-plant tests, their scope and plan. C. C. Georgeson.
- (14) The botany of the cowpea. S. M. Tracy.
- (15) Methods of soil investigation. F. H. King and M. Whitney.
- (16) The control of soil moisture. D. McLaren.
- (17) Methods of irrigation. L. G. Carpenter.
- (18) What should the professor of agriculture teach? G. E. Morrow and P. M. Harwood.
- (19) Laboratory instruction in agriculture. J. S. Newman.
- (20) Details of successful farmer education. W. M. Hays.
- (21) The relation of the experiment station to the agricultural college. L. Foster.
- (22) The field of bulletins, present and prospective. C. L. Ingersoll.
- (23) The press bulletin. C. E. Thorne.
- (24) Methods of testing farm implements. J. W. Sanborn.
- (25) Fiber production. G. Vasey and C. D. Smith.
- (26) The production of beet sugar. E. W. Hilgard and J. Wilson.

NOTE.—This section program is published as furnished by the section officers. The executive committee requests that topic No. 14 be presented in the section on botany, Nos. 18, 19, and 20 in the section on college work, and Nos. 21, 22, and 23 in general sessions, unless a new section should be organized on station administration.

SECTION ON BOTANY.

GEO. F. ATKINSON, of New York, chairman.

L. BRUNER, of Nebraska, secretary.

- (1) New Jersey peronosporæ for 1892. B. D. Halsted.
- (2) New or little-known weed fungi. B. D. Halsted.

- (3) Fruit rots, a study. B. D. Halsted.
- (4) The rusts of the cereals. H. L. Bolley.
- (5) Résumé of original work in potato scab. H. L. Bolley.
- (6) Notes on destruction of some fungi. H. L. Bolley.
- (7) Clover in North Dakota. H. L. Bolley.
- (8) Some experiments in the prevention of *Cucospora ribes* and *Cylindrosporium radi*. L. H. Pammel.
- (9) A ruta-baga rot. L. H. Pammel.
- (10) Crossing of cucurbits. L. H. Pammel.
- (11) Treatment of grape and tomato diseases. G. McCarthy.
- (12) Method for obtaining a pure culture of Pammel's fungus of root rot of cotton. George F. Atkinson.
- (13) A new damping-off fungus. George F. Atkinson.
- (14) Contribution to the biology of the organisms causing root tubercles of leguminous plants. George F. Atkinson.

LOCAL PROGRAM.

TUESDAY, NOVEMBER 15, 1892.

Opening session.

Addresses of welcome:

On the part of the State, Hon. M. J. Foster, governor.

On the part of the city, Hon. J. Fitzpatrick, mayor.

On the part of Tulane University, Col. W. P. Johnston, president of the University.

Responses.

Business of the convention.

EVENING SESSION.

Annual address of William Le Roy Broun, LL. D., of Alabama, president of the Association.

WEDNESDAY, NOVEMBER 16.

9 a. m.—General session.

1 p. m.—Visit to the Louisiana Sugar Experiment Station, Audubon Park.

7:30 p. m.—General session.

THURSDAY, NOVEMBER 17.

9 a. m.—General session.

1 p. m.—Excursion on steamer *War Eagle* to Chalmette and Southport.

7:30 p. m.—General session.

FRIDAY, NOVEMBER 18.

7 a. m.—Excursion to Baton Rouge, stopping en route at several sugar houses in operation, by the Mississippi and Yazoo Valley Railroad.

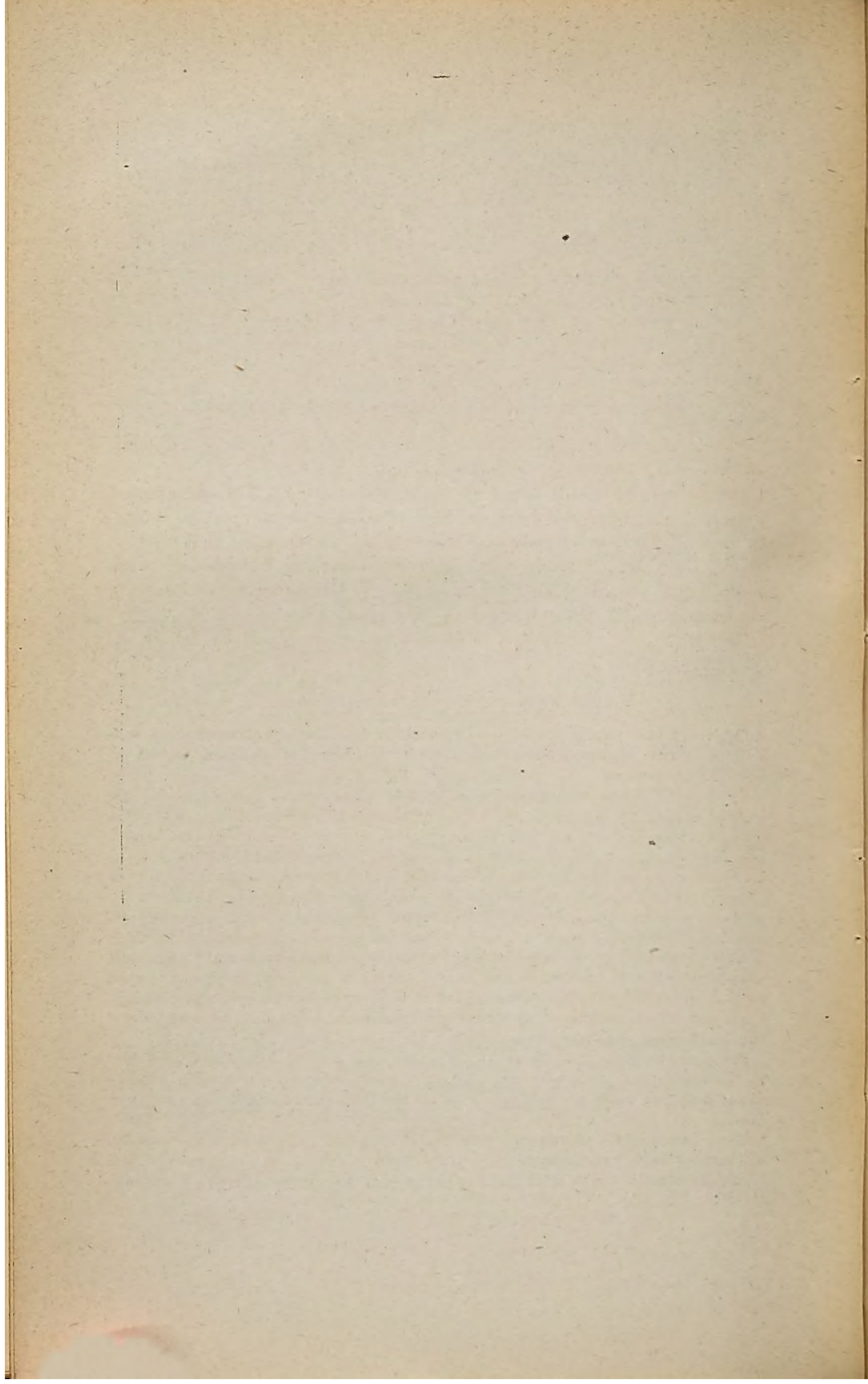
1 p. m.—Arrival and dinner at Baton Rouge.

2 p. m.—Visit to the Agricultural and Mechanical College and State Experiment Station.

4 p. m.—Leave for New Orleans.

7 p. m.—Arrive in New Orleans.

The public are invited to attend all the exercises of the convention, and especially those of the first day.



PROCEEDINGS.

MORNING SESSION, TUESDAY, NOVEMBER 15, 1892.

The convention was called to order at 12:10 p. m., in the lecture hall of Tulane University, by President Broun.

Prayer was offered by the Rev. B. M. Palmer, D. D., and addresses of welcome were delivered by Hon. M. J. Foster, governor of the State, by Hon. J. Fitzpatrick, mayor of the city of New Orleans, and by Col. W. P. Johnston, President of Tulane University. Responses were made by the president of the Association, by Mr. Atherton, of Pennsylvania, and by Mr. Chamberlain, of Michigan.

The report of the executive committee was submitted by H. E. Alvord, chairman.

REPORT OF THE EXECUTIVE COMMITTEE.

This committee met in Washington immediately after the adjournment of the convention of 1891, and organized by electing H. E. Alvord as chairman, and M. A. Scovell as secretary.

The committee has performed the duties with which it was charged by the last convention, and in accordance with the constitution of the Association has called the present meeting and made the necessary arrangements therefor. In this connection the very cordial and efficient local aid which has been rendered in New Orleans, under the energetic leadership of Director Stubbs, deserves appreciative recognition.

Comparatively little work has been necessary at Washington on behalf of the Association during the past year, either before Congress or the Executive Departments, and yet the influence of the Association has unquestionably aided in securing prompt payments from the United States Treasury to the colleges and stations; in maintaining the advance payments to the latter; in providing for the continued support and additional efficiency of the Office of Experiment Stations; and in obtaining a special appropriation for the Weather Bureau, to be used in work on the borders or common ground of meteorology and agriculture.

The committee has given especial attention to the several subjects referred to it by the Washington convention of 1891, and particularly the instructions relating to the proposed work of the Association at the World's Columbian Exposition at Chicago next year.

The question of the location of the collective exhibit of the colleges and stations was settled early in the year to the entire satisfaction of all parties concerned, and in the agricultural building of the Exposition a space has been definitely assigned

ample in area and admirable in position. Immediately adjoining space has been assigned to Germany and France in which to exhibit what these countries are doing for agricultural investigation and instruction. This fact should be an incentive to every institution affiliated with this Association to do its full share in order that the work of our American colleges and stations may be shown to compare favorably with that of foreign lands. No such opportunity of making this comparison where it will impress the people of this and other countries is likely to occur again for many years.

The work of preparing the coöperative exhibit of the experiment stations has moved steadily forward, and great credit is due to the standing committee of the Association having this matter in charge as well as to the Department of Agriculture for its generous and effective coöperation. A report of progress will be made by Director Armsby, the chairman of the standing committee.

The instructions of the last convention, as shown in the printed Proceedings, pp. 72 and 73, were carried out by the executive committee in the appointment of President Atherton, of Pennsylvania, President Smart, of Indiana, and Prof. Morrow, of Illinois, as the special committee to consider the subject of a collective agricultural college exhibit in connection with the station exhibit already determined upon, and with power to act for the Association in the premises. This committee canvassed the subject and received such encouragement from the various institutions as to lead to the decision to proceed with the work of preparing such an exhibit. President Atherton later found the condition of his health and the pressure of home duties to be such as to necessitate his retirement from this committee. The chairmanship was then urged upon President Smart, but he, for like reasons, felt compelled to decline and also to wholly retire from the work. Prof. Morrow was carrying such a burden of Exposition work in Illinois, as to be able to act on this committee only in an advisory capacity. The executive committee keenly felt the loss of the services of these efficient officers in this important undertaking, and as the time for the present convention was approaching it was decided not to reorganize this special committee, but to have the executive committee itself continue the work until further instructions from the Association. This has accordingly been done and a report of progress will be made by the chairman.

The special committee appointed by the Association to coöperate with the Congress Auxiliary of the Exposition in relation to agricultural congresses has been actively engaged, and its work will be reported by the chairman, Prof. Morrow.

After the adjournment of the last Washington convention the Association was invited to send one delegate to a conference arranged by the officials of the Exposition and the Columbian Dairy Association, for the purpose of formulating rules to govern the proposed tests of dairy cows at Chicago. Director Scovell, of Kentucky, secretary of the Association, was designated for this service by the executive committee, and his services in that capacity were most useful and influential. The reception of this delegate and the position accorded him in that conference was a notable recognition of this Association. Still more so is the final adoption by the Exposition authorities of the rules governing dairy tests, substantially as framed by that conference, and which provide that the committee to supervise the tests at Chicago shall have as its nucleus four representatives of this Association.

The executive committee has received from the chief of the department of agriculture of the World's Columbian Exposition formal communications addressed to this Association, requesting it to nominate four representatives of our body, to be appointed by the Exposition authorities to supervise the tests of dairy cows, and also to appoint a committee of the Association to confer with Chief Buchanan regarding a course of popular agricultural lectures to be delivered during the Exposition in the Agricultural Building.

This action throws upon the Association a very grave responsibility, making it virtually the arbiter in the most important and most carefully prepared experiment

in comparing the dairy breeds of cattle that has ever been undertaken. Various questions of duty, of expediency, and of ways and means arise in this connection which should receive the serious attention of this convention.

The executive committee has therefore assigned for Thursday morning next the consideration of the subject, "The Association and the World's Columbian Exposition," with all the incidental questions, and all delegates are requested to prepare for full discussion and appropriate action upon this very important matter.

Conforming to the action of the last convention, the executive committee has fully considered the subject of amending the constitution of the Association, and as a result it submits to this convention, in connection with the program for its proceedings, a printed draft of a constitution which is recommended for adoption as a substitute, entire, for the existing instrument. Action upon this subject is assigned for the general session of Wednesday morning.

The Washington convention appointed a special committee of three to confer with the officials of the Department of Agriculture upon the development and extension of the Weather Bureau in the special interests of agriculture. This committee has performed the duty assigned and will report thereon to this convention.

In accordance with the action of the section of college work during the last convention, confirmed by the Association, the annual reports to the Department of the Interior, from the presidents and treasurers of colleges, have been formulated, through the cordial coöperation of the Bureau of Education, to the satisfaction of all concerned. The relations of the colleges to this Department, through the Bureau of Education, as its agency for communication, have been agreeable and free from friction. Yet it is found that the new and arduous duties devolving upon this Bureau under the operations of the (so-called) new Morrill act, have to be performed without special provision therefor, and it is evident that many mutual advantages would accrue from some such additional organization as was made for the stations in the establishment of the Office of Experiment Stations in the Department of Agriculture. This is a subject which seems to be worthy of special consideration by this convention; accordingly a suitable assignment has been made for the general session Thursday evening, and in this connection the special representative of the Department of the Interior has been invited to address the Association at that time.

Other details of the proposed proceedings of the present convention will be found in the printed program, which is now formally submitted and recommended for adoption. It is also recommended that the rules of order which have governed former conventions be continued in force, and that, as heretofore, the executive committee be authorized to receive all credentials and prepare the official roll of delegates.

The contribution of \$10 for the year from each institution eligible to membership in the Association, as agreed upon at the last convention, has been very generally paid, and has created a revenue sufficient for the requirements of an economical administration. The principal disbursements the past year have been for the necessary expenses of committees while in the discharge of their duties. The treasurer's report will show a balance from last year of \$309.49, to which is added \$1,130 for collections, making the total receipts \$1,439.49; disbursements in all amounted to \$1,022.95, leaving a balance on hand of \$416.54 at the opening of this convention. It seems evident that the Exposition work of the coming year will involve additional and unusual expenditures, which the Association should consider and provide for before adjournment.

Respectfully submitted for the executive committee.

HENRY E. ALVORD,
Chairman.

NEW ORLEANS, LA., *November 15, 1892.*

The report was accepted and ordered on file.

On motion of Mr. Atherton the action of the executive committee in assuming charge of the preparation of the collective college exhibit for the World's Columbian Exposition was approved, and the committee was instructed to continue that work.

The report of the treasurer was then presented by Mr. Scovell.

The report was received and referred to an auditing committee, consisting of Messrs. Hadley, Hunt, and Newman.

Mr. SMART. I have suffered much from colleagues in search of information and I feel like making a protest. I have received within the last four months thirteen requests from thirteen different institutions for information about the institution I represent. One book-keeper wants the college accounts to the 1st of January and another to the 1st of July. I think such information ought to be supplied, and that it can be if we make proper arrangements. I move, therefore, that a committee be appointed by the chair to consider the subject of college statistics and to devise means for securing and distributing them.

The motion was carried, and the chair appointed Messrs. Smart, Atherton, and Goodell.

Mr. Alvord, chairman of the executive committee, announced that the convention had been invited through special committees to visit the cotton exchange, the sugar exchange, and the board of trade, and that Mr. Stubbs would furnish permits to visit the large sugar refineries of the city.

On motion of Mr. Alvord, representatives of the cotton exchange, sugar exchange, board of trade, Academy of Science of New Orleans, Tulane University, Illinois Central Railroad, and any other railroads having agricultural interests were invited to sit with the delegates in general sessions and in the sections.

The secretary requested delegates and visitors to register at once and get their numbered badges.

The convention adjourned at 2 p. m.

AFTERNOON SESSION, TUESDAY, NOVEMBER 15, 1892.

The meeting was called to order by the president at 3:40 p. m.

A letter inviting the Association to visit the Southern University was read by the secretary. On motion of Mr. Alvord, the invitation was accepted for Wednesday afternoon.

Mr. Turner, chairman of the section on college work, read his report, as follows:

REPORT OF THE SECTION ON COLLEGE WORK.

In presenting this report an explanation of its incomplete character is due the Association. On October 10 I addressed a circular letter of inquiry to the president of each college in the Association, asking for the information deemed necessary for this report. Replies to that circular have been received from twenty-five colleges. Some of these replies were so general that they could not be used for the purposes of this

report. The colleges reporting were Arizona, Delaware, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Massachusetts, Michigan, Minnesota, Mississippi, Nebraska, Nevada, New Hampshire, New York, North Dakota, Ohio, Oregon, Rhode Island, South Carolina, South Dakota, Tennessee, Utah, and West Virginia.

The inquiries submitted were in reference to increase in attendance, graduates, additions to the faculty, new courses of study, new buildings and equipment, and proposed improvements.

In reply to the first question, which was as to the increase of students in 1891-'92 over the preceding year, all the States named except Kansas, Kentucky, Massachusetts, Michigan, New Hampshire, and South Carolina report an increase for the year named, and some of them a still larger increase for the current year. Kansas accounts for a decrease by an increase of requirements for admission, Michigan by a diphtheria scare at the beginning of the year, Massachusetts by a controversy with the Institute of Technology over the Morrill fund. All of them, however, report very satisfactory work and very slight decreases. The South Carolina Agricultural College has not yet opened for work.

In number of graduates all colleges reported an increase except Arizona and Utah, which have not as yet graduated any students, and Illinois, Kansas, Massachusetts, Michigan, New Hampshire, North Dakota, and South Dakota; in some the increase is large, in others very small.

The third question asked for the increase in number of students in agricultural and mechanical courses. In most of the replies the numbers were consolidated so that it is impossible to tell what proportion of the reported increase went to each course. In Illinois, Indiana, and Oregon, where the number in each course is given, the tendency toward the mechanical course is very marked, there being in Illinois a decrease of 11 in agriculture, and an increase of 50 in the other; in Indiana an increase of 15 in agriculture and of 87 in engineering; in Oregon a decrease in the agricultural course and an increase of 20 in the mechanical course. In Kentucky and Nebraska the increase in the two courses is stated as 100 per cent.

Additions to the teaching force and new chairs are as follows: In eleven colleges chairs of mechanic arts, or engineering in some form, have been established, or additional teachers therein provided, namely, in Delaware, Illinois, Iowa, Kentucky, Mississippi, New York, North Dakota, South Dakota, and West Virginia. In addition to these, Delaware, Illinois, North Dakota, South Dakota, and West Virginia have added to their teaching force in agriculture; Kansas, North Dakota, and Oregon in English; and Kentucky, New York, North Dakota, and Tennessee have increased their teaching force in the natural sciences.

Replies to the inquiry as to the organization of new courses of study show that a new course in manual training or in mechanical, civil, mining, or electrical engineering has been established in the following colleges: Delaware, Illinois, Iowa, Kentucky, Mississippi, Missouri, Nebraska, Nevada, Rhode Island, Tennessee, and West Virginia, while existing courses have been enlarged and perfected in Kansas, Michigan, Nebraska, New Hampshire, North Dakota, and Ohio.

Increased facilities in the way of buildings and apparatus show progress all along the line. Probably the best way to indicate what has been done and what is proposed is to state what each college reports in answer to the inquiry on this point.

Arizona reports \$8,000 expended in apparatus.

In Delaware a wood-working shop and new recitation hall have been built and \$9,000 added in books and apparatus. A new machine shop and foundry will be added during the year.

In Illinois a science building costing \$70,000 has been erected and \$5,000 expended in apparatus. A new building for engineering is contemplated costing \$80,000 to \$100,000.

Indiana reports the completion of an engineering laboratory and equipment cost-

ing \$50,000, and it is proposed to build an extension to the shops and provide new quarters for chemistry and pharmacy and biology.

In Iowa the new buildings are an annex to the dairy for cheese-making, a new swine house, an office building, a new railway depot, and a new engine room. Additional equipment has been provided in physics, electricity, mechanical engineering, and the stock farm.

Kansas has built an iron shop and foundry, and expended \$4,000 in apparatus. Enlarged facilities for instruction and for the library are contemplated.

Kentucky reports a mechanical engineering building and equipment costing \$32,000, and equipment in other departments amounting to \$5,000.

In Maine there is a new engineering hall costing \$30,000, and increase in apparatus in all departments.

In Michigan a new botanical laboratory and greenhouse have been erected, costing 14,500; \$6,000 has been expended in books for the library and \$10,500 for equipment and apparatus in other departments.

Minnesota has erected a new mechanical shop, with equipments costing \$18,000.

In Missouri \$50,000 has been expended in buildings.

Nebraska reports a new gymnasium, a new shop and tools for manual training, clay modeling, and drawing. A new library building, to cost \$100,000, is in process of erection. Buildings and appliances for the experiment station and departments of agriculture, horticulture, and engineering are contemplated.

New Hampshire is about to remove her college to a new location at Durham, in order to obtain the benefit of a munificent endowment of land and money, amounting to \$1,000,000.

New York (Cornell) reports large additions to apparatus and equipment.

North Dakota has erected a \$40,000 building and an engine house costing \$5,000 and has added to the library and laboratory equipment. In the near future the erection of a dormitory, a chemical laboratory, and farm buildings are contemplated. A geological and library building, a building for mechanic arts, and large additions to apparatus are reported from Ohio. Improvements in the courses in mechanical engineering and agriculture are planned for the future.

Oregon has a new chemical laboratory and a dormitory for one hundred and twenty students and will soon erect a building for a dairy and one for horticulture.

Tennessee reports a new science hall costing \$60,000 for laboratories of chemistry, physics, engineering, etc.

South Carolina reports about \$150,000 expended in buildings; the college is not yet opened for instruction.

In Utah a new building to cost \$80,000 is in process of erection and \$20,000 have been expended in apparatus.

In West Virginia a commencement hall and gymnasium costing nearly \$20,000 have been completed; a building for mechanic arts and mechanical engineering with equipment has just been opened, costing about \$18,000, and a new Science Hall, to cost \$40,000, is in process of building. About \$5,000 is now being expended for books and \$3,000 for equipment in the departments. A new building for electrical engineering is contemplated and \$30,000 will be expended in equipment for the various departments.

SUMMARY.

These reports show great activity and enterprise in all the colleges and particularly the stimulating effect of the Morrill act of 1890 in pushing the development of industrial education. What may we not hope for the future of these colleges, when they have become fully equipped and when the annual income provided by this act can be fully devoted to the employment of teachers, thus broadening and deepening the channels of their influence?

I am constrained, however, to call the attention of the convention to one phase of these statistics. Where separate statistics of the numbers in the agricultural and

mechanical courses have been forwarded they show a most unequal advance in the agricultural and mechanical courses. What can be done to stimulate young men who expect to be farmers to take an education that will fit them for the best work on the farm? How can they be induced to come to the colleges and get the elements of an agricultural education in the study of physics, chemistry, botany, zoölogy, and mathematics? It seems to me that this is a problem which we have as yet not properly considered. I leave it for your thought.

E. M. TURNER,
Chairman.

Mr. FAIRCHILD. If I may be allowed to add a word to my report for the Kansas College, it is that we have added several instructors in the mechanical department, one in the horticultural, and several in the agricultural department.

Mr. SANBORN. I would like to add a word to the statement for Utah. The first year we had 139 students, last year 296, and at the present time we have more than 400. Two-thirds of the senior class of next year will graduate in agriculture. The faculty has been very much increased and now numbers 19.

Mr. LEE. The report of President Turner brings out a very important fact, and that is that the colleges are not doing the work for the agricultural classes that they should, and I suppose there is no doubt of the fact that the great industry of agriculture has been languishing. I have been impressed, Mr. President, for several years, with the fact that our colleges are sending forth scientists rather than practical men in the industries which the law intended to benefit. There is no doubt of the fact that comparatively few of the graduates of our colleges return from the colleges to agriculture. All of these institutions that have given statistics bearing upon that point show that only a small per cent go back to the farm. I think the Michigan college claims that about 50 per cent of the graduates return to the farm. The Massachusetts college many years ago used to send a good many men back to the farm, but I do not know whether that is being kept up now or not. As far as we can gather Mississippi has sent back from 40 to 50 per cent to the farm.

I think that this convention can not do better than try to find out what the trouble is and what the proper remedy. There is no doubt of the fact that the law of 1862 intended to benefit agriculture and the mechanic arts only by benefiting the classes engaged in them. I think all these institutions have had the desire to maintain a high standard of admission and graduation. That is right and proper, but I think we have gone a little too far in this matter. I think we ought to get nearer the class to be benefited. We ought to be more in sympathy with them, and I think the standard required of students in agricultural colleges is too high. The farmer's boy can not take advantage of them. The North has better common schools than the South. I will state here that in Mississippi and in the adjoining Southern States it

is almost impossible for a student to come up to the standard required in the freshman class, low as it is in many of the colleges. If the farmer is rich enough to send his son to the high school in town or some training school he may do it. But these institutions are intended to benefit agriculture and the mechanic arts, and if by putting our standard too high we have made a mistake, so that we send hardly any graduates back to the farm, I think we ought to try in this Association to remedy the trouble. We ought to put the diploma within the reach of every country boy. Let him come here and feel that he can get a diploma and that without being a scientist. There must also be a chance for the boy who wants to be a scientist. Let him take a post-graduate course if necessary.

Mr. ALVORD. As this is one of the subjects to come up before the section on college work and perhaps one of the topics which it will present to the Association, I suggest that we take up the report of the next section.

Mr. Ingersoll, chairman of the section on agriculture, presented the following report:

REPORT OF THE SECTION ON AGRICULTURE.

According to the clause in our constitution making it obligatory upon the chairman of a section to present a report at the annual meeting, I beg leave to present the following:

The period sought to be covered in this report dates from September 1, 1891, or soon after the adjournment of the convention of delegates at Washington, D. C.

Because the chairman, as well as other workers, becomes absorbed in the solution of the problems that are more immediately confronting him, and hence in a great measure loses sight of the whole field of action, and further because it was desirable to present the latest as well as earlier data, it was deemed advisable to address each station by circular letter, in order to obtain, if possible, prompt replies with reference to the work of the sections on agriculture proper in each of the experiment stations.

The letter was as follows:

DEAR SIR: As chairman of the section on agriculture of the American Agricultural Colleges and Experiment Stations, the duty devolves upon me to present a report of progress that shall be of a somewhat general character, yet specific enough to be of value in bringing before the section and the Association the full scope of the work undertaken and aggregate results.

To that end you are therefore earnestly requested to answer and return the following questions promptly, and oblige:

(1) What bulletins has your station issued since August 1, 1891, which are entirely or in part the work of your own department? State number and title.

(2) What work in progress not yet reported in bulletins? State by title briefly and, in a word, the degree of progress.

(3) What work has been undertaken or accomplished by collateral departments, as in soil, physics, meteorology, irrigation, engineering, and the like, which will be of interest?

Do not report work that will be reported upon in other organized sections, as chemistry, botany, horticulture, or entomology.

(4) State, in a short letter, your general condition as a station and in your own department, with interesting side statements.

To this communication I received thirty replies from the following stations, and, substantially, in the following order. It will be noticed that several of those farthest away were among the first to reply.

Kentucky.	Georgia.	Kansas.
Mississippi.	Michigan.	Indiana.
Utah.	Connecticut (New Haven).	Vermont.
South Carolina.	Colorado.	North Dakota.
Oklahoma.	Wisconsin.	Tennessee.
North Carolina.	Ohio.	New Jersey.
Wyoming.	Arizona.	New York.
Massachusetts.	Rhode Island.	Alabama (Uniontown).
Connecticut (Storrs).	Virginia.	Minnesota.
Nevada.	Texas.	South Dakota.

No substantial or descriptive reply was given to the four questions by the following stations:

Maine.	New Hampshire.	Pennsylvania.
Delaware.	Maryland.	West Virginia.
Florida.	Louisiana.	Arkansas.
Missouri.	Illinois.	New Mexico.
California.	Oregon.	Washington.

Several persons corresponded, incidentally, on other matters pertaining to the meeting.

In two cases parties addressed were in Europe, and we were notified of the fact, and in one case the director made a very full and complete reply for the person addressed.

After various vicissitudes in attempts at getting reliable information your humble servant and his clerk made an attack on the station files and found that subjects had been treated, in whole or in part, in all the stations as follows:

3 Farm manures.	1 Canaigre.
5 Soils and waters and tests of air and soil relations.	2 Irrigation.
1 Water and water analysis.	5 Tobacco.
24 Fertilizers, weeds as.	21 Corn, wheat, oats, etc.
3 Glanders.	19 Cattle and sheep feeding.
11 Potatoes, Irish and sweet.	1 Ramie plant.
1 Sulphur-curing of fruit.	6 Forage crops.
3 Food investigations.	4 Milk tests.
1 Nitrogenous plant food.	2 Rheumatism in horses, and diseases of sheep.
4 Silage and roots.	1 Horticulture.
9 Sugar beets.	1 Sugar cane.
4 Blue grass, hay, and timothy.	1 Comparisons of grain.
1 Electroculture.	2 Dehorning cattle.
1 Sorghum.	1 Kerosene emulsion for animals.
11 Dairying.	1 Inoculation.
1 Old and new meadows.	6 Dodder, weeds, and rusts.
2 Detasseling corn.	2 Farm practice with fertilizers to control insects.
1 Patent cattle food.	2 Organization.
3 Poultry.	1 Grasses of Tennessee.
1 Tuberculosis.	1 Corn fodder.
1 Cotton seed and meal for hogs.	3 Horse-feeding.
1 Liver flukes.	2 Veterinary.
1 Maple sugar.	3 Insecticides.
2 Seed and plant distribution.	
8 Cotton.	

When it comes to progress in work in which the stations were engaged, the thirty replies were scanned with care and it was interesting to attempt to group them so as to present them, in part at least, in a condensed form.

The following summary shows the number of stations on the lines of work as stated, or some modification of the work:

- | | |
|--|--|
| 3 Sugar beets. | 7 Variety tests of grain. |
| 1 Sheep-breeding. | 4 Green manuring. |
| 6 Steer-feeding. | 2 Detasseling corn. |
| 1 Analysis of wheat seed in various stages of growth. | 1 Carbonaceous <i>vs.</i> nitrogenous food for chickens. |
| 2 Cheese. | 1 Silage preservation. |
| 6 Fertilizer tests with wheat, corn, tobacco, and other crops. | 1 Sorghum <i>vs.</i> alfalfa. |
| 1 Coöperative fertilizer cotton tests. | 5 Soil physics. |
| 2 Corn <i>vs.</i> fertilizers. | 1 Scarlet clover. |
| 1 Apiary work. | 1 Horses. |
| 2 Plat tests. | 1 Milk separator tests. |
| 1 Farmyard manure <i>vs.</i> fertilizers. | 3 Feeding for milk, and sugar meal, gluten, meal, etc. |
| 3 Experiments with corn. | 4 Grasses and their management. |
| 1 Value of farm manure. | 3 Cowpeas. |
| 2 Milk tests for variation. | 1 Sorghum. |
| 1 Cañaigre. | 2 Potatoes, Irish and sweet. |
| 2 Irrigation. | 1 Pea-vine hay. |
| 5 Dairying. | 1 Plant nutrition. |
| 2 Pig-feeding. | 1 Insecticides. |
| 3 Coöperative field tests. | 1 Fertilizer map. |
| 2 Digestibility experiments. | 1 Sugar cane and rice. |
| 3 Sheep-feeding. | 1 Alkali soil. |
| 5 Tobacco. | 1 Corn fodder. |
| 3 Digestibility of peas, silage, corn, bran, barley, shorts. | 1 Forage plants. |
| 1 Milled products of wheat. | 1 Tile drainage. |
| 1 Silage <i>vs.</i> dry fodder. | 1 Experiments and continuous cultivation of corn. |
| 3 Variety tests of cotton. | 2 Cross-fertilization. |
| 1 Corn on drained and undrained land. | 1 Botanical survey. |
| 1 Farmyard manure tests. | 1 Chemistry of cotton plant. |
| 1 Poultry work. | |

The most interesting feature of the reports was the reply, in which, often in a single sentence, would be conveyed more information as to the work, the worker, and the station with which he was connected, than in a long report otherwise made.

Several complained of the lack of funds to perform the work they desired. No blame was attached to any person, only it appeared that too much had been attempted for the funds in hand. In some of the States there are indications of other funds being used to supplement the Hatch fund. This aid comes in part from fertilizer work in some instances.

It is pleasing to notice that the workers in agriculture are working along practical lines and at the same time doing their work more carefully and scientifically as they proceed. The men as a rule are not so hasty in their decisions, and do not reach conclusions at one gigantic bound nearly as often as in the earlier work of the stations. The matter of having tested plats on which to experiment—plats on which the factor of individuality is established or well indicated—is shown in the work of several stations. The removal of the factor of vacant ground next a plat, so that all conditions as far as possible shall be normal, has been followed by others.

In animal-feeding as a rule too many questions have been asked at one time and too much has been attempted in the way of proof. In our opinion but one or two

interrogations should be put to nature at one time; then try and remove all points of variation except the one sought to be proven, and establish that if possible beyond peradventure.

In this work we must make haste slowly or be obliged frequently to "thresh over old straw" or weave a fabric that to the veriest tyro will be like a sieve. Only a few stations feel the necessity of establishing checks in their work when experimenting with animals or of repeating their work for purposes of comparison. We are pleased to see this being done in two or three instances, and look for valuable results from interpretations of such work.

If it is found that under normal conditions and unchanged food we obtain results which vary as much or more than those found under changed relations, then we are simply unable to put an interpretation that is even approximate upon the compared results.

When, therefore, we received a statement that results in one station would be held for a year in order to compare another year's feeding, and that one of the factors in the work was the continuous feeding of one food to note changes in the milk and butter, we were pleased when we read the next sentence:

"The object of feeding the same food for a long period was to ascertain whether the variations between stated periods might not be as great as the variations when different foods were fed." A broad smile of satisfaction attested our approval of the work of that station. Other stations may be doing the same thing, but we are not apprised of the fact. It is our province to speak of that we have seen and know.

Again, it is a pleasure to see the way in which the agriculturists seize upon those things that seem to be an advantage to their States. Thus, the beet-sugar industry engages the attention of States in the northern belt; cane sugar, rice, cotton, and sorghum, those adapted to the culture of these products; tobacco, and the new method of curing, the States extending from Florida to Connecticut which raise this crop, and likewise a few of the Western States; feeding engages attention everywhere, as all States feed for milk and meat, two standard articles of food; forage plants, including grasses, engage the attention of nearly all the States, and alfalfa is a subject of special study in the West; rape is attracting considerable attention; *Lathyrus sylvestris* has done well in my own State, and merits further trial.

Besides the work in the agricultural sections but properly and intimately connected with it is the work of several stations in regard to meteorology, soil physics, irrigation and a few things like cañaigre in Arizona.

The study of the Yucca plant and the like for fiber is necessarily confined to limited areas.

One station says: "The work of our station is mainly practical, very little purely scientific. The station is doing fairly good work and in the midst of prejudice is gradually forcing its claims to recognition as a valuable aid to the farmers." Another says: "A series of farmers' institutes has been commenced and the continual growth of the mailing list indicates a gratifying interest in the work of the station on the part of the farmers of the State." And what seems to us to be more important than all the facts announced is that there have been no changes in the station force during the year.

Another writes that "the agricultural department has been very successful in the experiments of the year." The students and farmers are becoming more interested. A second edition of one bulletin was called for and the third will soon be issued, with an appendix.

Another says: "The field work has been of long-continued permanence and grows more and more valuable and more and more appreciated by the farmers from year to year. No attempt is made to elaborate, but rather to concentrate and do limited lines of investigation well. The funds of the station permit the employment of intelligent assistants, and the most improved utensils are employed in the work. The development of the agricultural department is satisfactory and the many visitors to the station find this of great interest."

Another says: "The station has a compact organization, everything convenient, and the work economically conducted. In a general way it embraces the field of biology, dairying, animal nutrition, plant nutrition, chemistry, horticulture, entomology, soil physics, and general experiments in plant growth, including tillage."

Another says: "The work of our station is more particularly in the line of dairy work, and we feel fairly well satisfied with its conditions and especially with the relations we have succeeded in establishing with the dairymen of the State. Our connection with them becomes more and more intimate each year, and especially in the matter of testing milk and of paying for milk at creameries and cheese factories by tests. We have reason to believe that our work has been of a good deal of value to them, if we do say it."

Another says: "All the appliances about the college and station, including stock, dairy, vineyards, etc., are used as a laboratory for the students in agriculture in its broadest sense as an 'applied science.'" The amount of foundation work in this station and one other, both new, has been enormous and merits especial mention. In another State students are sent out in charge of special work at substations established. The writer says: "A student put in charge of work thoroughly planned and frequently inspected beats other forms of substation management."

Seed distributions have been made in three or four of the more Western stations where the conditions seem to demand it and are favorable for a just appreciation of its worth.

Coöperation is urged by another, who says: "Not that all can agree, but that small groups of workers could be formed where the conditions were favorable to work on special agreed lines."

"This station is desirous of coöperating and I believe we are ready to coöperate with some others in dairy work and pig-feeding."

Another says: "We are endeavoring here to do such work as will promote the agricultural interests of our own State and at the same time contribute as much as possible to the advance of genuine scientific investigation," and another speaks of poor soil, much depleted by long cropping, and of the one great problem of how to bring it up and use better animal husbandry with diversified products. He says: "We have had no disaster from moving, fire, or flood." Several others have met one or more of these to their sorrow and temporary disadvantage.

Another says that the work is being appreciated more each year by the farmers. Five bulletins a year are issued. In another instance the general condition of the station is good. Experiments are carried on at six substations or experiment farms, five conducted with and one without irrigation. The superintendent of each farm is controlled by directions sent out from the head of each department of the university. Plans for experiments at all the farms are recommended to the experiment station committee of the board of trustees by the station council. This plan insures uniformity of plan and purpose at all substations and is considered advantageous. Efforts are to be made to establish experiments in stock-breeding, feeding, dairying, etc., at each farm, because of the prominence of stock-raising as an industry.

Another says: "The station force is extremely active and we have on hand much more material than we can publish on account of limited funds. The field covered by the station has become extremely extended and yet we see many problems which need to be investigated. The testing of varieties and field experiments have not so far yielded such wide results as have those which have been conducted in buildings where the conditions could be better controlled than in the field." We agree very fully with this writer and know that experiments of the latter class are more interesting to the worker and will give more positive results; yet if time is taken and the proper checks maintained, and further, if the factor of "individuality" or "personal equation" for each plat be properly looked after and as far as possible eliminated, then we may obtain much satisfaction from plat experiments.

In closing this dissertation I wish to thank those who have responded so promptly

to my request for information which for lack of time has been loosely thrown into groups. The tardy ones caused some delay in commencing the work. Perhaps they were too busy to stop experiments long enough to reply but are here and will give us in person what they have failed to send.

C. L. INGERSOLL,
Chairman.

The PRESIDENT. If there is no objection the report will be filed with the secretary. Next is the report from the section on botany.

Mr. TRACY. Prof. Atkinson, the chairman, owing to his duties at Cornell, where he has gone recently, is not present, and has asked me to read his paper.

Mr. Tracy then read the report of Mr. Atkinson as chairman of the section on botany, as follows:

REPORT OF THE SECTION ON BOTANY.

Since the last annual report was presented from the section on botany before this Association the force of botanical workers in the experiment stations has been increased by the organization of departments at the following stations: Arizona, Florida, New Mexico, South Dakota, and Texas, the officer at the latter station being horticulturist in charge of botany.

Several changes have been made in the working force. At the Alabama College Station, G. F. Atkinson retired October 1, 1892. At the Kansas Station, A. S. Hitchcock was appointed January, 1892, to succeed W. A. Kellerman. In Massachusetts, J. E. Humphrey retires January 1, 1893. In Michigan the station work has been reorganized, and C. F. Wheeler appointed botanist. At the New York Cornell University Experiment Station, W. R. Dudley retires to accept a position in Leland Stanford University, and G. F. Atkinson, of Alabama, has been appointed cryptogamic botanist.

At several stations where botanical work is carried on there is no regularly appointed botanist, that work being in charge of the horticulturist or entomologist. Since botanical work has come to my notice from several of these places it has seemed best to include it in the report. In view of this and the fact that several of the botanists have charge also of entomology or horticulture, or are given the titles mycologist or biologist, the official title is placed in parenthesis accompanying each station's work.

Alabama: P. H. Mell (botanist and meteorologist, has charge of phanerogamic botany) is engaged upon a study of the economic grasses and weeds of the State, and is crossing varieties of cotton. Mr. Atkinson (biologist, has charge of plant pathology) has continued his studies of cotton diseases, has discovered a new damping-off fungus, obtained pure cultures of Pammel's ozonium of root rot of cotton in Texas, and is studying the biology of the organisms which cause leguminous root tubercles.*

Arizona: J. W. Toumey is making observations on the adaptability of the native grasses, trees, and shrubs for cultivation.

Connecticut (New Haven): W. C. Sturgis is studying the diseases of tobacco and making experiments in curing tobacco and spraying fruits and garden crops. He is beginning a critical study of the Cribriariaceæ.

Delaware: F. D. Chester (mycologist) is engaged upon studies of *Monilia fructigena*; diseases of watermelons, muskmelons, and cucumbers, and the winter killing of blackberries. He has reached promising results in treatment of peach rot.

Florida: P. H. Rolfs (botanist and entomologist) has recently entered upon his duties.

* For continuation see Cornell University Experiment Station in this report.

Illinois: T. J. Burrill (botanist and horticulturist) is studying bacterial diseases of plants, raspberry rust, monilia of plum, and economic smuts.

Indiana: J. C. Arthur (botanist) is investigating the normal growth of the potato, and the relation of the number of eyes of a tuber or part of a tuber to the number of stocks produced and to the yield. He is also studying the enzyme in seeds of wheat and oats, the relation of green seed to early maturity, and wheat smuts, and has devised a method of preventing the rust and bacterial disease of carnations.

Iowa: L. H. Pammel (botanist) is studying the life history of *Peziza schlerotiorum*, *Rhizoctonia betæ*, and *Cercospora beticola*. He has experimented on the effect of fungicides upon roots and germination of seeds, crossing of cucurbits, treatment of plant diseases, and is at work on the chromogerm bacteria of the Ames flora, and anatomy of cucurbits.

Kansas: A. S. Hitchcock (botanist) is experimenting with fungicides on seeds and studying the biology of weeds, and economic Uredineæ.

Kentucky: H. Garman (entomologist and botanist) is engaged upon comparative study of foreign plants.

Maine: F. L. Harvey (botanist and entomologist) is making collections of economic plants.

Massachusetts: J. E. Humphrey (vegetable physiologist) has been studying black knot of plum, a violet disease, and a new disease of cucumbers, and is preparing a monograph of North American Saprolegniaceæ.

Michigan: C. F. Wheeler is consulting botanist.

Mississippi: S. M. Tracy (director of station) is making a botanical survey of the State and working on the Gramineæ, Southern tomato blight, and a new disease of the grape.

Nebraska: C. E. Bessey (botanist) is making an exhaustive study of native trees and shrubs, and native and cultivated grasses, and is at work on diseases of the sugar beet.

New Jersey: B. D. Halsted (botanist and horticulturist) is working on diseases of the cranberry, rose, violet, and hazel, and fungi of weeds, and experimenting on treatment of celery and sweet potato diseases.

New York * (*Cornell*): G. F. Atkinson (cryptogamic botanist) is engaged upon a study of winter blight of tomatoes, a botrytis disease of beans, carnation diseases, and damping-off fungi.

New York (*Geneva*): S. A. Beach (horticulturist) is studying the effect of copper compounds in soil on vegetation. He has obtained good results from Bordeaux mixture and selection of seed for anthracnose of beans, and from Bordeaux mixture for Septoria on chrysanthemums. He has also treated apple and potato scab, raspberry anthracnose, gooseberry mildew, strawberry leaf-blight, and celery diseases. He has, in coöperation with D. G. Fairchild, experimented on the effect of rainfall on pollination.

New Mexico: E. O. Wooten (botanist) is collecting plants for a herbarium.

North Carolina: G. McCarthy (botanist) does entomological work, is engaged in seed-testing and treatment of grape and tomato diseases, and is studying bacteria of nitrification.

North Dakota: H. L. Bolley (botanist) has found corrosive sublimate effective in preventing potato scab; is studying the fungus of deep scab of potatoes, making attempts at artificial cultures of Uredineæ, and working on the distribution of root tubercles of the Leguminosæ.

Ohio: Miss F. Detmers (botanist) is collecting the rusts (Uredineæ) of the State.

Oregon: M. Craig (botanist) is at work on weeds, forage plants, and plant diseases.

Pennsylvania: W. A. Buckhout (botanist) does entomological work, is engaged in

*The botanical department has charge of the experiment-station work in botany, which is intrusted to the cryptogamic botanist.

forestry and hybridization, and is working on the practical side of potato rot and downy mildew of the grape.

Rhode Island: L. F. Kinney, (horticulturist and acting botanist) has reached important results in the treatment of seed potatoes with Bordeaux mixture to prevent potato scab. He is also treating seeds.

South Dakota: T. A. Williams (botanist) is making observations on forage plants suited to varying conditions in different parts of the State and studying plum pockets and a geranium disease.

Tennessee: F. Lamson Scribner (director and botanist) has published a list of the grasses of the State in the form of a popular edition, to be followed by a more technical one.

Texas: R. H. Price (horticulturist) does entomological work and is engaged in treatment of cotton and grape diseases.

Utah: The entomologist acts as consulting botanist.

Virginia: E. A. Smyth, jr., has charge of phanerogamic botany. W. B. Alwood (horticulturist) is engaged in studying apple-leaf diseases and experimenting on weak solutions of copper salts for plant diseases.

Vermont: L. R. Jones (botanist) has made a test of the comparative value of a number of the standard fungicides on potato rot (*Phytophthora infestans*).

Wisconsin: E. S. Goff (horticulturist) is working on apple scab and experimenting on the germination of seeds.

In looking over the work of the station botanists it is interesting to note the number who are engaged in making use of artificial cultures in studying the life histories of parasitic fungi. Not only are the stations through this work constantly making important contributions to the biology of many obscure and little-known organisms, but they are making known many facts which have an important bearing on the treatment of the diseases produced by these parasites. The different habits and appearances of the real enemy are brought to light; its plans of attack are studied; proof of its harmfulness can be established by inoculation, and known causes thus supplant supposed ones. No other feature of botanical work at the experiment stations, in my estimation, is doing so much to lay the permanent foundations for a rational economy in the treatment of plant diseases.

The best work of this kind can only be successfully carried out with the aid of expensive modern apparatus appertaining to bacteriological laboratories. This provides the trained workmen with the means of proceeding rationally and accurately to the desired end. The stations which at the present writing are provided with such cultural apparatus are the following:

Alabama, Connecticut (New Haven), Delaware, Illinois, Indiana, Iowa, Kansas, Kentucky, Massachusetts (Amherst), New Jersey, New York (Cornell), New York (Geneva), North Carolina, North Dakota.

Several workers in other stations feel the need of cultural apparatus in their work. It is hoped that another year will find them provided with this want.

Steps were taken to determine the number of volumes in station libraries relating to botany, accessible to the workers. Sufficient data were not received to incorporate anything more than a general statement in this report to the effect that several of the stations, even those remote from the larger seats of learning, are building up surprisingly large and valuable libraries and herbaria.

Respectfully submitted.

GEORGE F. ATKINSON,
Chairman.

The PRESIDENT. If there is no objection the report will be filed with the secretary. Next is the report from the section on chemistry.

Mr. Scovell, chairman of the section on chemistry, presented the following report:

REPORT OF THE SECTION ON CHEMISTRY.

Early in September a circular letter was addressed to the chemists of the agricultural colleges and experiment stations, asking for a brief report of the chemical work completed or under way since the last meeting of this Association. To this letter twenty-three replies were received. It is evident from these replies that the chemists, taken as a body, are considering many subjects covering the field, from mere detective work to purely scientific investigations. Some forty different subjects are reported as having been considered. I would trespass beyond my allotted time were I to consider these various subjects separately, or even give the brief synopses of the reports received, which I have had compiled, and which are appended to this report.

Like my predecessor, I have endeavored to classify the various subjects considered, and for this purpose have adopted in the main his admirable scheme of classification. I have classified the subjects, therefore, under the following principal heads: (1) Detective duty; (2) work directly related to farm management; (3) work having in view the improvement of processes or the development of agricultural manufactures; (4) work of a more strictly scientific nature. Most of the work reported falls under one or more of these classes. It is not always easy, however, to tell under which one some of the work should come, as some reporters give the mere facts without giving the purposes of the work. Take, for instance, the analysis of feeding-stuffs. A number report having made such analyses, without stating whether it was for the purpose of giving the farmers information as to the purity or whether it was done in connection with feeding-experiments. Again, soil analysis might be mere routine work, or it might be an exhaustive investigation which more probably would come under scientific investigations. In the main, however, the reporters have not only outlined the work, but have explained sufficiently to readily classify it.

(1) *Detective duty*.—Detective duty or routine work undertaken to protect the farmer against fraudulent practices in the business world. Under this class is placed the routine work of fertilizer analysis when made for the purpose of verifying for farmers the statements of dealers, or for the discovery or prevention of fraud, either with or without fertilizer control; also the examination of feeding stuffs, dairy products, and other materials for adulteration.

(a) Fertilizer analyses: Eleven stations report work under fertilizer analyses, eight assuming fertilizer control. It is evident, however, that some of the stations reporting did not incorporate fertilizer control work, assuming, undoubtedly, that such work was not a matter of consideration here, as the funds for such work come from the State or from fees. [The analysis of fertilizers to detect fraudulent practice seems to be generally undertaken by those stations which are in the fertilizer belt.] None of the stations report that the fertilizer work prevents more important and at least more interesting work being done. One station distinctly states that the fertilizer control work is a source of revenue which materially aids it in other work.

(b) Feeding stuffs: But one station reports the analysis of feeding stuffs with the object in view of detecting adulterations.

(c) Adulterations of dairy products: Two stations report that they are doing work for dairy commissioners in the analyses of butter, etc.

(d) Detection of poison: One station reports a case of poison maliciously given to cows.

(2) *Work directly related to farm management*.—This includes a large amount of chemical work carried on for the purpose of determining or practically demonstrating for the farmer the best methods of carrying out farm operations, including such work as soil tests of fertilizers, feeding stuffs, the test of milch cows and dairy breeds, the preservation of manures, utilization of waste products, etc. All the chemists replying report work under this head as follows:

(a) Soil tests with fertilizers: Seven stations have been devoting some of their time to the chemical work in soil tests with the commercial fertilizers.

(b) Feeding experiments: Four stations report work in feeding experiments.

(c) Composition of plants: Thirteen stations are at work on the analyses of plants. Some of them are doing far more than the mere routine analyses. They are studying individual plants. When such is the case they are also given credit for work under the fourth general class.

(d) Analyses of plants at different stages of growth has occupied the attention of four chemists reporting.

(e) Analyses of newly introduced plants: The analyses of plants newly introduced when considered locally has been undertaken by four chemists.

(f) Test of milch cows and dairy breeds: Eight stations have had this topic under consideration. Some are at work making a comparative test of dairy breeds, others are analyzing the milk of individual cows for the purpose of studying the composition in relation to feeding experiments or for an object lesson to the farmer, showing him the necessity of weeding out the cows in the dairy which do not pay for their keeping.

(g) Analyses of manures, waste products, etc.: Eleven stations are giving their attention to the analysis of manures, waste products, etc., some of them devoting considerable attention to this, both as a matter of illustration and for the purpose of determining to what extent the waste materials on the farm and in the factories can be utilized in restoring the fertility of our soils.

(h) Soil and water analyses: Twelve stations are at work on the analysis of soils or waters, or both. Some few of the stations are giving a great deal of attention to this topic, and alkali soils and irrigation waters have been very generally considered by our Western stations.

(3) *Work having in view the improvement of processes or the development of agricultural manufactures.*—Under this class may properly come much of the chemical work in our creameries and sugarhouses, and also the study of the sugar beet, sorghum, and cane as to their content, the object being to develop an industry.

(a) Test of plants for sugar: Nine of our stations have been studying the sugar beet or the sorghum plant, some stations giving considerable attention to the sugar beet.

(b) Dairy problems: Seven stations report work under this topic. It is impossible in some instances to tell whether the work properly comes under this class or under detective duty, as the analysis of milk for creameries, etc. Some few of the stations are entering extensively into the chemical problems involved.

(c) Milling: One station reports a study of milling products.

(4) *Work of a more strictly scientific nature.*—Under this head may be placed the comparative study of soils, plants, and foods; analyses for the purpose of studying plant physiology and nutrition; digestion experiments; a study of the food of man; and studies of chemical methods and apparatus, the object being the improvement of methods for the sake of accuracy, saving of time and convenience, or for the development of methods and invention of apparatus in original investigations. At least three stations are taking up the soil question. Three stations are studying the tobacco plant and as many are at work on the cotton plant. The loss of nitrogen in the development of plants has been considered by one station. A number of stations are at work in or arranging to undertake digestion experiments. Thirteen of the stations reporting have been to a greater or less extent studying chemical methods and apparatus.

From the reports it is to be clearly seen that while the chemical work of our stations to a great extent has been, and probably will continue to be, of a routine nature, the value of which should not be underestimated, nevertheless considerable work of a higher nature is being undertaken or contemplated in the near future. The thorough equipment of many of our stations and the additional force being employed gives an opportunity for a more thorough and systematic study of chemical problems.

The time and attention given to chemical methods by nearly all our stations, as evinced by the work reported to the Association of Official Agricultural Chemists, is indicative of progress. When we consider that nearly all of our stations have been organized in the past few years, that many of our workers were necessarily inexperienced in practical work, we can but wonder at the work accomplished and the accuracy of the results obtained. I feel it but justice to say that much of this credit is due to the Association of Official Agricultural Chemists. The uniformity of methods—methods tried by the crucial tests of experience, a great saving of time by the use of such methods, the shortening of the work of our chemical engineers by tunneling through rather than going around obstacles—have enabled our stations to do much thorough, accurate, and comparable work, which never could have had the value it has save for the training and assistance our chemists have had in and by our Association of Official Agricultural Chemists.

ABSTRACTS OF REPORTS FROM STATION CHEMISTS TO THE CHEMICAL SECTION.

C. B. Collingwood, of the Arizona Station, reports that their chemical work has been (1) a study of the character of water used for irrigation and its effect on the soil and on plant growth; (2) the character of the soluble material in the soil and the effect which water will have on it; (3) best methods of curing alkali soils; (4) investigations as to the per cent of tannin in cañaigre. Canaigre is a *Rumex* indigenous to the arid region, which contains in the green root about 10 per cent of tannin. By cultivation for one year it is found that the same amount or sometimes more tannic acid will be formed. So far the chemical work of the station has been along the line of analysis of waters, soils, and native plants, which may become of economical importance.

G. L. Teller, of the Arkansas Station, summarizes their work as follows: (1) The study of methods of analysis in connection with the Association of Official Agricultural Chemists; (2) a study of the loss of nitrogen during the growth of certain plants; (3) the study of the composition of the cowpea in the different stages of its development; (4) compilation of other experiments in agricultural chemistry, published in Bulletin No. 19.

D. O'Brine, of the Colorado Station, reports work in the following lines: (1) Manure; (2) the loco question; (3) milk, sugar-beet, and soil analyses.

E. H. Jenkins, of the Connecticut State Station, reports of the chemical work of the station, aside from the routine of fertilizer control, fodder analyses, milk tests, and the assistance rendered to creameries in introducing a system of milk-testing: "We have studied somewhat methods of cheese analysis. Our chief work, perhaps, has been the inauguration of experiments designed to extend over a term of years to test the effect of fertilizers on the quantity and especially the quality of the Connecticut wrapper leaf tobacco, the final judgment of quality to be made after the leaf has gone through the fermentation and is ready for the cigar manufacturer."

Mr. C. D. Woods, of the Connecticut Storrs Station, reports that the principal chemical work of the station during the last year has been: (1) Routine analysis in connection with the study of the food of man; (2) feeding experiments with animals; (3) the analysis of crops grown in field experiments.

E. H. Farrington, of the Illinois Station, says: "The chemical work of this station for the past year has been mostly on the analysis of milk, sugar beets, soil, and feeding stuffs. I am making some investigations of Grandeau's method of estimating *matière noire* in soils; also observations on the soil moisture in the first 6 inches of corn land throughout the season." Dr. Farrington reports that he is doing considerable work under the topic of developing analytical methods, especially in feeding stuffs and the use of improved apparatus. He is using a 1-horse power electrical motor for running a Babcock milk-tester; also an automatic pipette for measuring the acid in milk-testing, and reports that it has proved to be efficient and practical when properly constructed.

H. A. Huston, of the Indiana Station, reports that they have been engaged upon work with phosphoric acid and sulphate of alumina on corn, field experiments on the forms of nitrogen for wheat, improvement of the so-called bogus soils—both field and laboratory work—rate of souring milk under different conditions of setting and examination of butters produced, feeding and fertilizer value of pursalene, the study of chemical methods, and other miscellaneous matters.

G. E. Patrick, of the Iowa Station, reports for the chemical work of his station as follows: (1) Effect of feed upon quality of milk; (2) sugar beets in Iowa; (3) sweet *vs.* sour cream butter; (4) chemical work in calf-feeding experiments; (5) soiling experiments; (6) feeding beets and potatoes for butter; (7) soil analyses.

In the chemical laboratory of the Kentucky Station work has been carried on in the following lines: (1) Daily tests of milk in connection with a feeding experiment for butter fat as well as for comparing the milk of different cows, analysis of butter in connection with the above experiment, analysis of feeding stuffs in connection with the above feeding experiment and also for farmers; (2) tests of sugar or varieties of cane grown at the station; (3) analysis of potable and mineral waters, marls, and soils; (4) examination of miscellaneous materials sent in by farmers and others; (5) examination for poison in viscera of a number of cattle (the results of this work aided in the conviction of one person for cattle poisoning); (6) determination of specific gravity of all the varieties of potatoes raised at the farm, with a few determinations of dry matter in the same; (7) work on methods of analysis in connection with the Association of Official Agricultural Chemists, and analysis of a number of honeys; (8) the whole of the work of the State fertilizer control, besides the analyses of several grasses grown at the station, is now in progress.

H. J. Patterson, of the Maryland Station, reports that the work of the chemical department has been chiefly with the tobacco plant on (1) the effect of fertilizers on the composition of the ash and burning qualities; (2) the effect of different methods of curing on the organic constituents; (3) fodder work in connection with the feeding and digestion experiments; (4) analyses of marls, limestones, and fertilizers used in experiments.

C. A. Goessmann, of the Massachusetts State Station, reports that the lines of chemical work have been (1) analysis of licensed fertilizers; (2) analysis of commercial fertilizers or manurial substances; (3) analysis of agricultural chemicals, a refuse material used for fertilizing purposes; (4) analysis of fodder articles; (5) analysis of water; (6) analysis of butter and butter-fat substances for the Massachusetts State dairy bureau; (7) investigations on the effect of the application of different fertilizers on the condition of plants.

H. Snyder, of the Minnesota Station, reports that work in the chemical laboratory of the station has been under the following lines: (1) in dairying, the manufacture of cheese from milks rich and poor in fats, the incorporation of cream into cheese, losses in cheese-making, artificial curing of cheese, and the development of acid in cheese-making. (2) Digestive experiments with milch cows—pea silage and wheat bran; with pigs—barley, barley and shorts, corn, corn and shorts, bran, peas, etc. In these latter experiments complete analysis has been made of the food and in the case of the cows the milk also. (3) Analysis of the beets grown by farmers in the different parts of the State, and tests of varieties of beets and sorghum. (4) The composition of the wheat plant in its different stages of growth, and the analysis of different grains of wheat and all the milled products from the same. (5) Analysis of the main fodder and grain crops of the State. (6) Soil collection and analyses. (7) Analysis of water and milk samples sent by farmers, and other miscellaneous work.

W. L. Hutchinson, of the Mississippi Station, reports that the chemical work for the station during the past year has been on grasses, marls, water, cotton plants, and milk.

F. W. Morse, of the New Hampshire Station, reports that the work pursued in the

chemical laboratory of the station has been (1) a study of the effect of feeding upon the composition of butter fat; (2) investigation of maple sap, sirup, and sugar with reference to the season; (3) composition of fodder corn with reference to the amount of seed per acre and the investigation of nitrogen-free extract in the same; (4) development of analytical methods.

New Jersey has been at work on (1) analyses of commercial fertilizers. (2) Analysis of fertilizing materials, manures, waste products, etc., (*a*) for the purpose of giving exact information as to their character and composition; (*b*) to indicate economical methods of buying and using. (3) Analyses of farm crops, (*a*) to determine the character and value of newly introduced plants; (*b*) to determine the effect upon the composition of potatoes and sweet potatoes, of the use of different kinds, forms, and qualities of plants and qualities of plant food. (4) The study of chemical methods. We have tried the Gunning method for the determination of nitrogen both in the presence and absence of nitrates; the Ulsch for nitrogen and nitrates; modifications of the official method for the determination of potash; and the drying of fats in air and hydrogen after extracting according to the official method.

A. Goss, of the New Mexico Station, reports that the chair of chemistry of the New Mexico College of Agriculture and position of chemist to the station have only lately been created, and he has no work to report.

H. B. Battle, of the North Carolina Station, gives the following synopsis of the chemical work done by the station: (1) Analysis of commercial fertilizers; (2) investigations in connection with the analysis of cotton seed and cotton-seed meal; (3) analysis of marls and limestones—work in connection with the development of analytical methods for the Association of Official Agricultural Chemists; (4) identification of ores, minerals, etc.; (5) iron ores; (6) mineral waters; (7) investigations with tobacco with reference to composition; (8) study of the composition of native and wild grasses and various feeding stuffs; (9) digestion experiments; (10) study of sorghum as to its sugar content.

G. L. Holter, of the Oklahoma Station, reports that the station has just been organized and that he has no work to report.

G. W. Shaw, of the Oregon Station, reports that the Oregon Station has been confined to two lines: (1) Work on the sugar beet; (2) an investigation of the Oregon soils.

H. J. Wheeler, of the Rhode Island Station, reports that the chemical work of his station during the year embraces the analyses of commercial fertilizers, factory refuse of agricultural value, fodders, well and spring waters, and a systematic analysis of the algæ which appears on the Rhode Island coast, with special reference to their fertilizing qualities.

M. B. Hardin, of the South Carolina Station, reports the chemical work of the Clemson Agricultural College as being confined to (1) the analyses of feeding stuffs, sugar beets and fertilizers; (2) an examination into the character of phosphoric acid in cotton-seed meal and the ratio of available to the total phosphoric acid, and of the water soluble to the total potash in such meal. Analyses of official samples of commercial fertilizers have also been made at the South Carolina station.

C. W. Dabney, of the Tennessee Station, reports the chemical work done by the station: "We have completed and published a bulletin on the cotton plant. This is a chemical study of the cotton plant and all its parts and all the products of the cotton-seed industry. We have also analyzed a number of feeding stuffs, samples of milk, butter, etc. Most of our time work has been given to a systematic study of the soils of Tennessee. The soils of East Tennessee have been completed, and we are now at work upon the soils of other sections of the State. The station also makes the analyses for the State bureau of agriculture in connection with the fertilizer control."

H. H. Harrington, of the Texas Station, reports the study of grasses and forage crops. The soils of the State have been given attention by this station and they are just beginning to study animal foods under special conditions.

J. L. Hills, of the Vermont Station, reports that the work of the chemical department is largely in connection with the dairy, and has covered about three thousand analytical samples of dairy products; also with the manufacture of maple sugar and sirups, and fertilizer control; together with fodder analyses in connection with feeding experiments, and the study of analytical methods.

R. J. Davidson, of the Virginia Station, reports the analysis of feeding stuffs, fertilizers, and marls, and a special chemical study of the tobacco plant.

E. E. Slosson, of the Wyoming Station, reports that the chemical work of the station has been on the following lines: (1) analysis of sugar beets; (2) analysis of soils; (3) analysis of mineral waters of the State; (4) analysis of native and cultivated grasses.

M. A. SCOVELL,
Chairman.

The PRESIDENT. If there is no objection the report will be filed with the secretary. Next is the report of the section on entomology.

Mr. OSBORN. Prof. Bruner is not present but has sent me his report, with the request that I present it to the association. It is as follows:

REPORT OF THE SECTION ON ENTOMOLOGY.

While there is still a certain amount of ridicule entertained for the "bug catcher" or entomologist, this feeling of apparent disgust on the part of the general public for himself and his "pets" is rapidly disappearing. Consequently it has even been acknowledged, in a quiet sort of way, that some of these misguided mortals are harmless fellows. It has also been asserted on one or two occasions that they are not "bad;" when everything is taken into consideration, they do not differ very much from other people. But—well, no matter.

There has been no great change in the personnel of the entomological workers in the stations and colleges during the past year; hence it has been thought best not to repeat the report of a year ago and that of two years ago. We have had reports on the work being done by different members of the society of station and college economic entomologists from year to year. This year, therefore, I thought it might be well to digress a little from the custom of the past and report on the equipment of the various institutions for this work. I accordingly sent out personal letters to all of the working entomologists of the society, asking for concise statements respecting the equipment of the departments under their respective charge. These letters were replied to by a number of the entomologists addressed, but others have thus far paid no attention to them.

Judging from the reports received, the different institutions in the East are apparently much better equipped for entomological work, both as to reference libraries and apparatus with which to work, than are those in the West. They are also provided with more and better room than we in the western part of the country can boast of. This, when we take into consideration the fact that the East also contains most of the large reference libraries of the country, does not speak well for the institutions of the West. True, there are extenuating circumstances which should be taken into consideration before we criticise too severely. The Eastern States have been settled much longer and are more thickly populated. The insect pests have also had more time to increase and become spread over that region than they have had in the West. On the other hand we in the new West transact our agricultural business on a much larger scale than do our Eastern friends. Our insect pests, while perhaps fewer in number of species, are greater in number of individuals of each species. These must be handled over hundreds of acres, whereas in the East they are dealt with on only a few acres.

Of the thirty-odd workers the country over, it will be seen from a perusal of the following reports that a number of them are provided with special buildings or

insectaries, with greenhouse attachments, in which to carry on their investigations. Others of our number are without these aids. Some are supplied with ample means for both field and laboratory experimentation against the insect pests of their respective localities, while others have hardly anything in the shape of these aids, and scarcely more than the bare space in one corner of a small room with which to attack the host of insect enemies which they are supposed to control.

As would naturally be supposed, the workers who are best equipped and at the same time well supported by the governing boards of their respective institutions, have been and are now doing the best work. Economic entomology does not mean the mere gathering and pinning away in boxes of a number of miscellaneous insects, as many people seem to think, nor do any of the workers who have been engaged to fill these positions wish to make such their trust.

What we need as workers who are expected to accomplish much in economic entomology, is the following equipment: (1) Good and ample room to work in; (2) first-class reference libraries and collections of typical specimens, along with sufficient apparatus in the shape of breeding cages, jars, microscopes, cameras, drawing tools, materials, etc.; (3) machinery for the application of insecticides in laboratory and field; (4) sufficient appropriations to enable us to carry on our experimental work with insecticides and other methods of insect control on a sufficiently broad scale to insure success. Without support of this kind it is wrong to expect the workers in economic entomology to accomplish great results. Give us an opportunity to prevent the great annual losses sustained by the agricultural and other interests of the country from the ravages of depredating insects, and we will do our utmost to meet this demand.

Standing at the head of the economic entomological work of the country is the Division of Entomology of the U. S. Department of Agriculture. This is in charge of Prof. C. V. Riley. Without this branch of government work to fall back on the various workers in the stations and colleges would be much hampered in their researches in economic entomology. Assisted as he is by so many special workers, Prof. Riley has been able to make the Division a vast storehouse of information on the life histories and habits of most of our indigenous insects. With the good reference libraries and collections at hand any doubtful question that may come up in the several stations of the country can be quickly settled in Washington. It is the Mecca to which all entomologists of the country journey. Recently the building of a typical insectary for use in connection with this Division of the U. S. Department of Agriculture has added to its usefulness. Not only are there a number of workers located in the rooms of the Division at Washington, but there are also a number of field agents distributed over the country, where they are occupied in making special investigations on the insects in the regions where they are located. The equipment of this Division is nearly perfect. No report has been received.

The following reports from the institutions heard from will indicate about the condition of equipment of the various institutions of the country that are more or less engaged in the study of economic entomology:

Alabama, although not having a special entomologist, carries on this line of work in the Alabama Polytechnic Institute. The work here is in charge of Prof. Geo. F. Atkinson, the professor of biology. He reports as follows: "With all this work on hand (pathological and mycological), I can at present do little in entomology, and the comparatively small equipment for insect study would not be worth mentioning." The professor, however, states that his institution is very well equipped for bacteriological and mycological work, his library and collections in that direction being very good. He also states that he has a special hothouse for the study of fungi, etc.

From Arizona J. W. Toumey reports that "the department of entomology at this station has been in operation less than a year. As yet the library is poorly supplied with necessary reference books on the subject; however, we hope to make considerable

additions in this line in the near future. We have a reference collection of nearly two thousand specimens, many illustrating species of economic importance. The university being located in a non-agricultural region, but few field experiments have been carried on; however, during the summer I will spend two or three weeks at Phoenix in the special study of the injurious insects of that region. We are well supplied with necessary machinery for the application of insecticides. We have been especially investigating the insects injurious to canaigre (*Rumex hymenosepalus*), a plant the economic importance of which we are investigating as to its value as a source for the supply of tannin."

In Arkansas there is no separate department for the purpose of investigations in economic entomology, although there is engaged at the Arkansas Industrial University a professor, J. F. McNeill, who is an entomologist.

California is well equipped for work in this line, and not only has an experiment station entomologist, C. W. Woodworth, but also a professor of entomology in the College of Agriculture. There are, in addition to these, two special agents of the U. S. Department of Agriculture located in the State. The San Francisco Academy of Sciences is provided with a good reference library, to which the entomologists have access.

The State of Colorado has an entomologist, C. P. Gillett, who is connected with both the experiment station and the agricultural college. He is provided with an assistant. His report reads as follows:

"For apiary experiments there has been erected a good honey house, with storage and work rooms and cellar. I have thirteen colonies of bees and an abundance of furniture and tools to work with in the apiary. The insect collection probably numbers not less than 10,000 specimens, all of which have been taken in the past year and a half, and the number is rapidly growing. We are putting special stress on collecting and rearing insects this year. Our breeding-cage numbers for this year have reached 261 to date, (July 28). I keep an accessions and a species catalogue and a breeding-cage record, with a system of cross references, and as full data as possible are kept of everything that enters the collection. To contain the collection I have 112 Harvard boxes, 75 Schmitt boxes, and 25 other boxes for which I know no name. The section is also fairly well equipped with the various insecticides and pumps and other apparatus for applying the same. I am allowed one good assistant, who devotes most of his time to station work. The station has use of the microscopes, photographic apparatus, etc., belonging to the college."

Connecticut does not report any special work in this line.

M. H. Beckwith, of Delaware, reports that the entomological work of this station is carried on in connection with the horticultural work, and in consequence of not having an assistant the time has to be divided between the two departments, often to the detriment of one or the other of the lines of work.

"The library contains about one hundred and fifty volumes, principally on economic entomology. We have no reference collection except such as I have been able to secure in connection with my routine work. The facilities for breeding and studying life histories are a glass house and breeding cages similar to those illustrated by Dr. Riley in his Missouri report. Various field experiments are carried on to control the curculio, corn weevil, strawberry weevil, peach aphid, cankerworms, codling moth, rose bug, cabbage worms, etc. We are well provided with machinery for applying insecticides, having five Nixon pumps, upon which we use the $\frac{1}{4}$ -inch hose, with fittings for the large nozzles. We also have a Japy knapsack pump and several Vermorel nozzles, one Lewis combination pump, and the Brooks hand pump, but we use the Nixon pumps and nozzles in preference to all others in our work. Much of our work is distributed in different parts of the State. Numerous lectures have been given before grange meetings, horticultural societies, and farmers' institutes. *Anthonomus musculus* has been very numerous on strawberries in several localities in the State. I found blossoms infested with the larvæ and have bred per-

fect insects from them. We are experimenting with *Botrytus tenella* on the white grub."

I have received no report from Florida, but there is entomological work carried on in this State; the name of the station entomologist is P. H. Rolfs.

Georgia, I believe, is without an entomologist, either in the experiment station or in the State College of Agriculture and Mechanic Arts.

The Illinois College and Station work is united under the charge of Prof. S. A. Forbes. The equipment for work is excellent and the results obtained are among the best in the country. The insectary, which is used in the study and rearing of insects, is one of the best equipped in the country. Library, reference collections, and everything else are among the best. Several assistants are provided by the State. Field control of insect pests and the study of bacterial diseases of insects have been leading features of experimenting in this State.

In Indiana there is no station entomologist, but the subject is taught in the School of Agriculture, Horticulture, and Veterinary Science of Purdue University by J. Troop. I have no report of equipment and facilities for teaching from this institution.

The Iowa department of entomology is quite strong, both in the agricultural college and experiment station. The work in both is in charge of Prof. Herbert Osborn, who is provided with an assistant for the station work. He reports as follows:

"Library facilities embrace the college library, the station library, and my private library. As these duplicate each other only in a few cases the aggregate is an excellent working entomological library, containing almost all of the current entomological literature and many works which are out of print and rare. Of special works I may mention Buckton's British Aphides, Piaget's Les Pediculines, Guebel, Epizoa, full sets of Psyche, Canadian Entomologist, Proceedings and Transactions American Entomological Society, and Riley's Reports as among the important ones. The collections are quite extensive, twenty-four glass-top cases 15 by 18 inches, and two hundred or more boxes (Schmitt pattern) belonging to the Station; besides these the full college sets. They are especially full and valuable in native Lepidoptera, Coleoptera, and Hemiptera, while other orders, especially Orthoptera and Neuroptera, are quite well represented. In many cases the determinations are by well-known specialists, and great pains have been taken in all orders to secure correct identification of species. In Hymenoptera the Ichneumonidae and Tenthredinidae are well represented. In Diptera some of the families are fairly well represented with determined material. The Hemiptera, including my private collection, contains an extensive series, and of parasitic insects, especially Pediculidae and Mallophaga, it is perhaps one of the best in the country. In Arachnida (spiders, mites, and ticks) it is fairly well supplied. In all orders biological material is accumulating rapidly, and some special collections showing insects affecting certain crops are already formed or in progress.

"The section owns a first-class microscope, with powers ranging to a one-twelfth inch oil immersion, and various accessories, and has also at command the numerous equipment in microscopes, microtomes, etc., in the college laboratory of zoölogy and entomology. A breeding room, about 25 feet square, is devoted to breeding cages and equipment for tracing life histories, while root cages are provided for outdoor work and space in the station greenhouse is available during winter or at any time when necessary for special conditions. An apiary is kept, at present consisting of half dozen full colonies and two nuclei, one of which is kept in an observation hive for study. Studies of clover insects are in progress, and experiments upon control of Jassidae in pastures. We have a variety of spraying outfits and nozzles, hopper-doers, etc., and supplies of various insecticides, which are tested to determine their merit or their adaptability for certain kinds of insects or effects on certain plants. We have numerous queries regarding injurious insects, and much time is devoted to correspondence. My own time is divided between college and station duties."

From Kansas no report has been received, but we know that the entomological work in that State is well taken care of, both at the agricultural college and the State university. At each of those institutions are located well-known entomologists, at the agricultural college E. A. Popenoe and at the university F. H. Snow. The experiments relative to the control of the chinch bug by means of a bacterial disease have become widely known as work being done at the university, while insect pests of especial interest to the horticulturist are being successfully studied at the agricultural college and station. The principal workers at both of the institutions have assistants provided. The equipment at both is good.

Prof. H. Garman, of the Kentucky Station, writes: "At the station I have charge of entomology and botany as one department and have fitted up two rooms on the first floor for work in these lines. One of these is provided with a desk, a drawing table, and bookcases and is used entirely for manuscript work. The other and larger room is fitted up as a laboratory, with tables for microscopic and insect work and with one large table for bacteriological work, this line being pursued both as a branch of entomological work and as a division of botany. In the laboratory are cases for insects and also for plants. The rooms are provided with gas and water and the usual apparatus, such as microscopes, bacteriological sterilizers, setting frames, breeding cages, racks for vials, etc.

"The collection of named specimens numbers in the neighborhood of 1,800 species. Most of my material is not yet determined.

"In the way of books we have the standard works, such as those of Harris, Saunders, Curtis, Fitch, Riley, Lintner, Lubbock, McLaughlan, Buckton, Westwood, Say, Le Conte, etc., and have the more important serials, such as Proceedings Entomological Society, Philadelphia, Transactions American Entomological Society, Canadian Entomologist, Entomologica Americana, etc.

"In the college I have the department of zoölogy and entomology, and teach the latter subject to all students taking the biological course and those for the agricultural courses. These students are required to make a careful study, using the microscope and dissecting needles when necessary, of types of all important orders of insects; and learn the use of analytical keys by determining material furnished them or collected by them. They are required also to become familiar with common injurious species and with approved remedies for their injuries.

"I have one regular assistant, who helps in both station and college work; when more help is required I draw upon students.

"The station is also supplied with the usual apparatus for spraying and for the application of insecticides."

From Louisiana H. A. Morgan writes that "the entomological department has but recently been added to this institution, and that in connection with another very heavy branch of work, namely, horticulture. Until this summer nothing was done in this line except investigation that might go on without much expense. Early this spring breeding cages were procured, a portion of the propagating house set aside as a temporary insectary, and the different field force pumps and knapsack sprayers were purchased.

"We have a collection already of about forty cases; a great many of the specimens I collected while studying at Cornell.

"Our entomological library is by no means the best; however, our board are gradually feeling the pressing necessity of advancing this work and are furnishing us with good works from time to time. The literature we have is very general.

"Our investigations up to the present have been along economic lines, associating as much of the scientific with our work as possible. We have worked with the screw worm fly, horn fly, sugar cane borer, sweet potato borer, corn bud worm (*Diabrotica 12-punctata*), orange dog (*Papilio cresphontes*), pecan and walnut moth (*Actias luna*), cotton worm, bollworm, and to some extent with many others.

"I have found it very difficult to carry on any work, having the two departments without any assistant in either, in both university and experiment station. I have,

however, persuaded our board to separate the departments and to give me entomology alone, the separation to take effect October 1.

"I am at present working on the orange scales, and have made arrangements for the importation of the parasites upon the red scale (*Aspidiotus aurantii*), which have been recently imported into California. I have also made arrangements for the trial of the hydrocyanic acid gas treatment.

"For teaching facilities I have been furnished with a number of charts and three Auzaux models, also good microscopes and general laboratory facilities."

The entomological work in Maine is in charge of Prof. F. L. Harvey, who states that "The experiment station has no laboratory, but I use the natural history laboratory of the college and my private quarters at my house for experimental work. I am provided with microscopes, microtomes, and other apparatus usually found in biological laboratories.

"We have a collection of 1,000 species of insects of various groups. The college, station, and my private library include the most of the economic entomological publications. We have no specially fitted breeding apartments. I have to use my library, laboratory, and private workroom for such purposes.

"I have been studying the past season for recreation a species of mite known as the verbena mite. I have studied our Maine species of *Thysanura* and *Odonata*.

"We have force pumps of several patterns."

E. W. Doran, of Maryland, reports as follows: "You are aware that this is the first year here and that nothing has been done here in entomology before. There were no collections worth mentioning and no appliances or library. There is some spraying machinery, such as pumps, etc., in the hands of the horticulturist that can be and has been used by that department in that line heretofore. We have only about 1,000 species of insects in our reference collection, and the library of entomological works is small. Our breeding facilities are meager. I am getting the matter started. No special line of investigations has been carried on, but the work is such as becomes necessary by outbreaks. I am giving nearly all of my time to teaching and get no salary for services at the station."

Prof. C. H. Fernald, of the Massachusetts College (Amherst) writes, in reply to my queries, that "there are two experiment stations at this place, one, the Massachusetts State Station, supported by the State, and the other the Hatch Station, supported by an annual appropriation from the general government. The State Station has no entomologist. I am acting as entomologist of the Hatch Station in addition to my duties as professor of zoölogy in the college and entomological adviser of the Gypsy Moth Commission.

"We have an insectary here for our work, which consists of a story and a half wooden structure with a greenhouse connected with it. The main house contains a laboratory, office, insecticide room, anterooms, etc., with storeroom, stenographer's room, and janitor's room above. The basement contains a pupa room, heating apparatus, coal bin, etc. The greenhouse is so divided that one part can be run as a hot-house and the other as a cold house. In the office we have a library of about one hundred and fifty volumes on economic entomology, and we are well supplied with pumps, nozzles, and other apparatus for applying insecticides both in the field and in the insectary.

"We are making a card catalogue of the literature of North American insects and this already includes more than 25,000 cards. These are made up from the entomological works in my own library, the library of Amherst college, and also that of the agricultural college. This last is very full and contains many rare and valuable entomological works. This card catalogue is exceedingly useful, for when I wish to look up any insect the card of that insect gives all references to the literature.

"We are making up a biological collection of all our common insects, comprising eggs, inflated larvæ in all molts, pupa, imagos, and parasites, also their work on the plants.

"The work done here thus far has been that which seemed to be demanded, judging from the letters that come in from different parts of the State. The work of experimentation is first done here in the insectary and then repeated in the field."

While I have received no report from Michigan, I know that the entomological work in that State is being ably looked after by my friend, A. J. Cook, in the agricultural college. Judging from the amount of work that he has done and the quality of it their equipment must be good.

O. Lugger, of the Minnesota Station, has not sent me a report of his equipments for entomological work in connection with the experiment station and college of agriculture. Whether his facilities for work are good or not, his work has been of such a character as to make some of the entomologists envious of him.

In Mississippi the entomological work is under the care of H. E. Weed, who writes me as follows: "When I came here the station authorities seemed to think that the entomological work of an experiment station should consist entirely of field work, and that no laboratory or anything of the kind was necessary. I was hence given only a 6 by 6 corner in the general office of the station. In six months I was given more space in a room used also for a library for the station. Here I was until last January, when I was given the room I occupy at present. This room is 20 by 20, with a dark room in one corner used in photography. In addition to this I have a building 10 by 15 feet in which I store my pumps, insecticides, etc., and do a little breeding in jars.

"The library, which is chiefly my individual property, consists of about 200 volumes, and is being added to daily.

"The collection comprises only such material as I collected last season and this, and it is contained in 40 Harvard cases. It is arranged in a duplicate collection, a study collection, and an exhibit collection. This latter is arranged so as to show insects injurious to special crops, along with their work and remedies. This collection was exhibited at several fairs last fall and attracted marked attention. Besides the station collection I have a private collection made before coming here, which is used for reference. It is about the size of the station collection, and is especially good in Coleoptera.

"A Coddington lens is the only microscope of which the entomological department of this station can boast, and when a better one is required it must be borrowed from the department of botany.

"The station is provided with the following insecticidal machinery: A Roach poison distributor, Legget's Paris green gun, orchard and garden pump, aquaject, Eureka knapsack, and Woodason's bellows.

"Especial attention has been given during the year to insects injurious to cotton, stored grain, cabbage, and beans."

In the Missouri Station and College the work in entomology is in charge of the professor of agriculture, C. A. Keffer. No report has been received in reference to the equipment and work of this station.

"The department of entomology in the Nebraska Station and Industrial College is under the charge of myself. No provision is at present made for an assistant in either the station or the college. The equipment here is as follows: We have a good reference collection, embracing about 10,000 species of insects of various orders. These are contained in 200 double boxes made by Stromberg, of Galesburg, Ill., 100 Schmitt boxes, two cabinets of the Schmitt pattern, and about 150 other boxes of miscellaneous make. In addition to these we have some thirty display cases of our common injurious and beneficial insects arranged along with their food plants to show their work, etc. Our alcohol material in preparatory stages, our spiders, and myriapods, are contained in about 1,500 vials. Much of this material is as yet unarranged and unnamed. The library, if we include all the works that are contained in the station, college, and in my private set, will perhaps reach 750 volumes besides a number of smaller papers. We lack, however, such works as the principal miscel-

laneous publications of Westwood, Curtis, and others, which are of the utmost importance to the economic entomologist. Our library as a whole is quite complete in works on Orthoptera, on the Aphididæ, Arachniæ, and American periodicals.

Breeding facilities are practically out of the question at present, for the entire department, station and college, is limited to a single room scarcely large enough for a comfortable office. This one room serves as office for the station work, library room, private work room, collection room, breeding cage room, and laboratory for students, of which there are upwards of twenty in different lines of work. Our laboratory equipment for student and private work is fair, there being three high-grade and six good laboratory microscopes in the two departments of the institution. Of wall charts we have all that we desire, as well as other appliances of like nature. These and reference collections with the boxes to contain the latter we have had no difficulty in obtaining; but books and breeding facilities, with machinery for field experiments, though asked for, have not been provided. Consequently, our equipment in these lines is almost entirely wanting.

No special line of investigation is at present under way here. The station work in this line has been almost entirely dropped for the time to give way to teaching. Sugar beet insects have been studied in the field to some extent during the past summer as well as this could be done without funds and appliances. The near future, however, promises to better this state of affairs.

From F. H. Hillman, of Nevada, no report has been received. He is entomologist and botanist for the station and teaches the two subjects in the college.

There does not appear to have been any report from New Hampshire, where the entomology is in charge of Prof. C. M. Weed. That he has the best that can be obtained from the board of control in his State can be relied upon.

A very encouraging report comes from Prof. J. B. Smith, of New Jersey, and reads as follows:

"My laboratory is fully equipped for all kinds of investigation into the structure or classification of insects. The optical aids—lenses, microscopes, and drawing cameras—are ample in every direction. Dissecting tools, reagents, and apparatus for histological investigation are complete, and as a study laboratory I have little left to wish for. The library on the subject is very full. We have not only the leading economic publications, but also all the current periodicals, native and foreign, and have in most cases full sets of each journal, including such as the *Annals of the French and Belgian Societies*, the *Berliner, Deutsche, and Stettiner Zeitschriften*, and indeed a well selected and full series of the best entomological works. To this I am adding constantly and have nothing to complain of under this head. I may add that we have all the records and publications of like character.

"The collections are good and growing. At present they fill 150 cabinet boxes, 15½ by 18½, and the same number of smaller book boxes, 9 by 13; in the Lepidoptera we have an excellent general collection; in the Cleoptera a well-selected series, representing the American families; and in the other orders chiefly a collection of local forms. This collection, embracing nearly 6,000 species, has been almost entirely secured by myself during the three years of my connection with the station. There are 33 boxes illustrating the economic insects as treated in the station bulletins. The facilities for raising or breeding insects are poor, and I confine this work to the closest possible limits. The State is small, and nearly all parts of it are readily reached by rail in a few hours, so that it is easy to study the insects in the field, and I feel the want of an insectary less than might be the case otherwise. Of insecticide machinery, we have enough to illustrate and make practical experiments. I have the leading types of nozzles, to exhibit and for use. My method of work is to select some one or more crops which are most troubled by insects, fix upon the most convenient points for their study, and spend as much time in the field as is necessary to enable me to learn all that I consider needful concerning the insects. During the present year insects infesting sweet potatoes and the Cucurbitaceæ are being specially studied."

From C. H. T. Townsend, entomologist of the New Mexico Station, we have received the following report:

"I have secured all the standard entomological, zoölogical, and physiological works. I have also 10 large breeding cages, after the Department of Agriculture style; 2 hand spray-pumps, hose, cyclone nozzles; 1 Woodason bellows; a complete outfit for preparing liquid insecticides; 2 achromatic triplets; 50 insect boxes, from Schmitt; 10 gross assorted vials, with rubber corks to fit; and 40 large glass jars for alcoholic material.

"I have no special line of investigation. Everything here is new, and each receives the same attention. I have already notes on 275 species. I also have a large number of fine alcoholic specimens, about 200 vials. Of the 275 species, probably 100 are named, if not more.

"The office, which is in the basement, consists of only one room, and serves also as laboratory and recitation room combined. It is provided with two tables, a desk, two large upright cases with glass doors, for holding insect boxes, vial boxes, and supplies, a letter press, microscope, etc."

Even if there has been no report received from New York we know that the entomology in that State does not suffer for the lack of equipment and a place in which to do the work. Prof. J. H. Comstock, of the Cornell Station, was the first to erect a special building for the purpose of rearing and studying the life histories of insects. Aside from this insectary the institution is one of the best supplied institutions in the land as to library and reference collection.

No report has come from the North Carolina Station or College.

In North Dakota there is no entomologist either in the station or the agricultural college, but this line is attended to in a limited way by Prof. C. B. Waldron, of the college, who is arboriculturist. No special equipment is provided.

In Ohio the subject of entomology receives attention both in the college and at the experiment station. In the latter it is under the care of F. M. Webster, who also acts as a special field agent for the U. S. Department of Agriculture. He reports as follows: "The consulting entomologist is employed jointly by the station and the Department of Agriculture, has no classes, but devotes his whole time to original work, and also has charge of the entomological correspondence. By agreement he furnishes to a great extent his own library, though the station purchases entomological works when necessary. The station has a fair reference collection of insects, and the entomologist also has a private collection which is used in the regular official work. The station has a microscope, with accessories, and a full supply of the latest improved machines for the application of insecticides. The last legislature appropriated \$1,000 to be used for the erection of an insectary building on the new grounds at Wooster, and this will probably be in shape for occupancy the present year. It will be equipped with facilities for the study of the development of injurious, beneficial, and other insects.

"While new facts relative to the morphology of any insect will be secured as far as possible, rather more stress is placed upon such as depredate on field crops. While not for a moment losing sight of the value of purely scientific investigations, the stations will lose no opportunity to make such investigations of practical utility to the agriculturist, in whatever branch of the industry he may be engaged. This it hopes to accomplish by a combination of field and laboratory work. The technical features of entomology will not suffer neglect, and it is hoped that at some future time we may be able to publish an annotated list of the insect fauna of Ohio, which shall be of value not only to this but adjoining States as well. For this purpose specimens and notes are being secured whenever an opportunity is offered."

From the Oregon Station, the entomology of which is in charge of F. L. Washburn, we have received the following report:

"The library contains about 70 bound volumes, and about 60 unbound pam-

phlets, insect reports, monographs, etc., also files of the American Naturalist, Entomological News, Zoe, Psyche, Insect Life, etc.

"Insecticide machinery.—A large-sized Bean sprayer, bamboo rods, the new Vermorel nozzles, the Nixon nozzle, the new Bean nozzle, a No. 3 Nixon spray pump, Little Climax pump, and a Leggett London purple gun for dry insecticides; also 10 gopher and mole traps; and a tank mounted on wheels.

"Five Packard breeding cages (old style). Breeding jars. The collection contains about 1,200 insects, representing from 500 to 700 different species. Forty-seven insect boxes in case, collecting tools and mounting material."

"In addition to these the department has, in connection with zoölogy, eleven compound and four dissecting microscopes, dissecting tools, etc.

"Some of the work in progress is experiments with the codling moth, including observations on the date of appearance of moth, length of time required for eggs to hatch, date of egg-laying, and length of life of moth; the comparative excellence of several insecticides; study of the hop louse and experiments against it; experiments with potash salts against cutworms and wireworms; and minor experiments against plant lice, flea beetles, and common pests of the garden."

No work in economic entomology is specially provided for in either the Pennsylvania State College or station.

The Rhode Island Station, I believe, is without a special entomologist. The work in Brown University is systematic rather than economic.

The South Carolina Station is without an entomologist and no entomological work is provided for in the college.

In South Dakota the entomological work is in charge of Prof. I. H. Orcutt, assisted by Mr. J. M. Aldrich. The department is united with that of zoölogy in both the college and station. The report from there is very encouraging. They have an insectary and are provided with six pumps of different kinds, breeding cages, etc. The collection comprises much unarranged material, and about 2,000 named species in all orders, chiefly in Coleoptera and Diptera. The library contains most of the economic and some of the systematic works on American insects. Some experiments have been made with kerosene emulsion as a sheep dip for scab. Experiments will be made on cutworm control during the summer and fall. A collection for the World's Columbian Exposition will be made.

Tennessee is without an entomologist in both station and college.

Texas also seems to be without an entomologist at present.

At the Utah Station the entomologist and horticulturist are the same person, Prof. E. S. Richman. He also teaches horticulture and botany in the agricultural college. No report has been received from there.

The entomological work in Vermont is looked after by Prof. G. H. Perkins, who is also professor of natural history in the University and State Agricultural College. No report has come from there.

From Virginia, where the entomological and botanical work are carried on by Prof. William B. Alwood in both station and college, the following short report has been received:

"For teaching and station work I have seven rooms, main office; private office; private laboratory; main laboratory, which is also lecture room; working laboratory for preparation of poisons, fungicides, etc.; and two small storerooms. This comprises entire ground floor of the main building. The library is my private collection of principal American works and of a few foreign. The collections are mostly private, and comprises about 3,000 species, embracing all orders. Breeding facilities are not good, but cages and greenhouse are used. Field experiments are few, made only to decide upon value of methods, etc. Machinery is the very best and well used. We have placed much machinery throughout the State and taught farmers how to use it. I am working especially upon tobacco insects and those affecting fruits. I have this year an artist assistant, one of my students, and am preparing a number of illustrations, especially on the life history of *Protoparce carolina* and *Chloridia rhexia*."

The Washington Station has no special worker in economic entomology and hence no report has been received.

Mr. A. D. Hopkins, of the West Virginia Station, reports in detail, but the equipment of this station can be summed up about as follows:

A single room 18 by 18 feet, fitted up with desk, bookcase, working table, and insect cabinet containing 36 drawers and 27 insect boxes. There is also a shelf at window for microscopic work, office, and other chairs, with the usual fixtures for work. In the library are something over 200 works on entomology. For working, a good high power and a dissecting microscope with material, and for collecting and rearing insects a good line of material and tools are named, while the equipment of insecticidal machinery is quite complete. The records of bred and collected specimens reach 5,686, while he reports 214 card notes and index and 250 pages of unpublished manuscript. In the collection there are contained 15,100 insects and 1,050 specimens, showing food habits. Some 250 unpublished original figures are also mentioned.

Special lines of investigation are, (1) the study of fruit and forest tree Scolytidæ; (2) the study of and investigation of forest and shade tree insects. All of this equipment and work has been accomplished in a trifle over a year.

While there is no entomologist at the Wisconsin Station, there is a teacher of economic entomology in the college of agriculture. Prof. E. S. Goff has charge of this branch along with horticulture.

Prof. F. J. Niswander, who has charge of entomology in the Wyoming Station, teaches entomology and zoölogy in the university and has charge of the experimental farm. He reports as follows:

"The books of reference are Transactions American Entomological Society, Riley's Missouri Reports, Packard's Guide, and Garden Insects by Treat, with such of the Government reports as can be obtained. I have a dissecting microscope and have to make my own breeding cages, etc. The department gets no appropriations from the board. I have one small spray pump.

"The following outline of work has been submitted to the council: A study of the injurious insects of the season and the best means and remedies for their destruction; the answering of correspondence concerning insect outbreaks, with suggestions as to best methods of destruction, and also as far as possible the study of their natural history; the publication of short newspaper articles from time to time, as occasion demands, giving the most approved methods of fighting insects; instructing the superintendents of the experiment farms with regard to collecting and preserving insects and taking observations concerning insect pests; the building up of a collection of Wyoming insects, to become a part of the equipment of this department; and the preparation and collection of material for the World's Columbian Exposition in 1893."

From J. Fletcher, of the Canada Station, who is both entomologist and botanist, this report has been received:

"The collections are small and are such as have been made since the organization of the Government experimental farms in 1887. There is no special insectary, but as there is no teaching all of our (mine and one assistant's) time can be devoted to correspondence and breeding and remedial experiments. The chief apparatus used are Galloway knapsack sprayers, a pump attached to a barrel, and a hand pump (Johnson's aquaject). The investigations made during part of the year, *Gortyna innanis* in hops, *Hæmatobia serrata* on cattle, *Coleophora fletcherella* on apple, *Fenusa melanopoda* on alder, *Nematus pallidiventris* on poplar, *Ellopiæ* (?) on oaks, and parasites. I have an unlimited supply of jars for breeding, and free scope to try agricultural experiments in the field. I have been without an assistant until this year, and now I hope to get my collection in order and be ready next spring to do more effective work."

L. BRUNER,
Chairman.

The PRESIDENT. If there is no objection, the report will be filed with the secretary. Next is the report of the section on horticulture by Prof. Popenoe, of Kansas.

Mr. FAIRCHILD. Mr. Popenoe is not present nor did he say anything to me of a report to be presented to the Association.

Mr. PLUMB. The question brought up by Gen. Lee was left, as I understood it, to be discussed in the section on college work. As I think it has a wide bearing and many who are interested in the subject would not be able to hear the discussion in the section on college work, I move that this subject be brought before the general session.

Mr. INGERSOLL. There are three gentlemen present to read papers before the section on agriculture on the subject of the teaching of agriculture. I would like to have these papers presented to the general session.

Mr. PLUMB. It seems to me that these papers are technical and should be presented in the sections, but the question raised by Gen. Lee is of general interest and ought to be discussed before the general session.

Mr. HAYS. Prof. Harwood and myself, who are expected to read papers before the section on agriculture on the subject referred to, are of the opinion that if the subject is of general interest the papers might as well be read before the general session.

Mr. HARWOOD. It seems to me that if Gen. Lee's question is taken up now the same thing will be gone over when our papers are read.

The PRESIDENT. It has been moved and seconded that the paper read by President Turner be discussed in the general session at this time. What is your pleasure, gentlemen?

The motion was carried.

Mr. SANBORN. Three years ago, after fourteen years' experience in agricultural education in the New England States and the Mississippi Valley, I was called upon to organize an agricultural college on the Pacific slope. In the several months which I had to think over the subject of organization and the studies to be embodied, I went over the ground very carefully and arrived at some of the following conclusions. In the first place, I read the law very carefully and tried to interpret it for the greatest good to our people. Farmers from ocean to ocean are supplied with agricultural colleges and technical schools of instruction in agriculture. The law under which they exist states that their general purpose shall be to teach the branches of learning—let me emphasize this—that relate to agriculture and the mechanic arts, in order to give a liberal and practical education to the industrial classes.

In organizing our institution we provided five industrial courses, agriculture having a prominent place. At this time I was writing for the agricultural papers throughout the country to interest them in the college. I said, "Agriculture is the leading industry of North America; the law says that we shall teach agriculture, the farmer demands that

every effort shall be put forth in his behalf. We shall do everything possible to make agriculture a leading feature in our institution, but after all it will rest with the farmers to determine whether the agricultural department shall be the leading one. If the demand for the mechanic arts should prove stronger, do not say that we have turned the cold shoulder to agriculture."

We have put our money into a fine farm, have erected buildings, and have established classes in mechanics, horticulture, biology, and other special lines. My friends, the trouble is that there is not a demand for agricultural instruction, and the fault lies not with the colleges but with the farmers themselves. A young man came to me a short time ago with a letter of introduction and said that he wished to enter one of the departments of the institution. I said to him, "I suppose you intend to turn your back on the farm and go into the city." He replied, "No, I am going back to the farm." I asked, "Then why don't you take a course in agriculture?" "Why," said he, "I have just come from farming." The farmer does not perceive that agriculture rests upon science and that until he goes to college and studies the science of agriculture he will be unable to do the best work. One reason why young men leave the farm for the city is the want that they feel of mental activity. When they discover that mental activity is of use in farming they will go back to the farm. The demand for agricultural education is increasing and twenty years from now it will be the fashionable education. In less time than that the tide of migration from the city to the farm will set in.

Mr. FAIRCHILD. May I ask Mr. Sanborn a question? I would like to know whether he can tell us the proportion of students taking the course in mining, mechanical, and civil engineering, and agriculture.

Mr. SANBORN. Not definitely. Of the junior class two-thirds of the students are in agriculture, in other classes the number is about evenly divided between that and other courses.

Mr. HENRY. If there are only three or four in a class that is not significant.

Mr. SANBORN. We have sixty juniors and thirty sophomores.

Mr. FERNALD. Twenty years ago it was my pleasure to attend a convention of the American Agricultural Colleges in Washington, and the principal topic at that convention was how to induce young men to study agriculture, and in every convention down to this time that topic in some form or other has been brought up for discussion. I do not know that we are any nearer the solution of the question than we were years ago. I believe that no question more vital to the interests of our institutions will be raised during the meeting of this Association than this one on which I hope to get light. The law requires that we teach the branches of learning related to agriculture and the mechanic arts. It is my observation and experience that when in the same institution you open the doors to mechanic arts and to agriculture, the young men

will turn toward the mechanic arts. An effort has been made in my own State of Maine to change this. We desire to see the number of young men taking the course of agriculture increased, but we find that even the students who come there for that purpose, when they see that it is better and easier to take civil or mechanical engineering, drop into those courses in large numbers. We can not help it. If the gentlemen here will point out a way by which we can bring equal numbers into these courses they will do us an important service. A farmer will ask me why we do not turn out more agricultural students—more who go back to the farm—but when I ask him what course he wishes his son to pursue, he says he wants him to take a course in civil and mechanical engineering. The farmers send their boys to college to take the other courses. I expect that the same thing is true in every State. New Hampshire has just received an endowment of nearly a million dollars for an agricultural college. I asked Director Whitcher whether they were going to introduce courses in civil and mechanical engineering. “Yes.” Then I said to him, “From the first, there is where your students will be.” “Yes,” he said, “I know it. We can not help it. I expect the students to go into these courses.” And they will. If New Hampshire should shut out the department of mechanic arts, making a purely agricultural college, the difficulty would be avoided.

So long as other doors are open the remedy for it has not yet been found. Whether there is a remedy is the question to which we should address ourselves. We might lower the requirements for admission to agricultural students. We have opened short courses, one for two years, and invited the young men to enter, but they do not want to come. We are proposing to open a short course in dairying by winter lectures. But these are really makeshifts and do not meet the demand for an agricultural course. How shall we induce students to take the four years’ course?

But even if our agricultural students do not go back to the farm we need not be entirely cast down. When the course in agriculture is taken what difference does it make how the knowledge obtained is applied? I claim that a graduate in agriculture is doing better service for agriculture as director or chemist of an experiment station, or as editor of an agricultural paper, than if on a farm. So when a farmer asks me why we don’t turn out more farmers, I make a long answer and it seems to satisfy him.

Mr. LEE. Eight or nine years ago a gentleman just elected to preside over one of the leading institutions in the Southern States when asked what he was going to do, said, “I am going to establish a department of mechanic arts and a department of agriculture, and I shall endeavor to direct our institution so that it shall be entirely in sympathy with agriculture.” [Applause.] I hope I may be excused for making a personal allusion.

Why do graduates from West Point make good soldiers ? It is because they are educated to be soldiers. When a boy goes to West Point he sees nothing that is not military. When he goes into the library he sees pictures of Scott, Sheridan, Grant, and other distinguished soldiers, and he sees the shelves covered with military books. While he is there his eating, his drinking, and his sleeping are military.

What is the case with our agricultural colleges ? There is no industry so attractive as farming. When a man goes to an agricultural college, agriculture should be presented in its most attractive style. He should see the best cattle kept in the best style, should see plowing done with the best plows and the best teams ; when he goes into the orchard he should find the very best fruits, and when he goes into the garden he should see the best vegetables. Make agriculture attractive in every way so that when the boy wakes in the morning he will see beauties in the farm.

It is only too evident often that the colleges are not in sympathy with farming. The Mississippi College is young and can not make a comparison with the Michigan and other colleges in the older States, but I can say that our college is becoming somewhat attractive to the farmer. For four or five years alliance men coming by would turn their heads the other way, but the sentiment has changed all over the State. The prejudice is almost broken down and I feel confident that in five years we shall stand in the same relation to our farmers that the Michigan College holds to hers. We shall not be asked by the legislature how much we want, but how much we can use. We expect to conduct our farming so that when a farmer comes there and compares it with his own work he will see the advantage of scientific agriculture. I believe that the lack of interest in our agricultural courses exists simply because we do not give enough attention to agriculture.

Mr. SANBORN. I would like to ask whether anything is done to keep boys from going into other courses which the law is equally clear in requiring us to teach.

Mr. LEE. Only this. We pay students for labor on the farm, but not for working in the shops. I say that the work in the shops is education only and does not deserve pay, but that work on the farm earns money and should be paid. Our mechanical department has been established this year and about one-half of the boys have gone into that department, but I find that they are now coming back to the agricultural courses in order to earn the money paid for the labor on the farm.

Mr. SMART. The question before us is a very old question and has been discussed in the same old way for many years. I want to contribute the speech I have been making for the last five years. I think a good deal of the blame for this thing is to be laid to the tariff, the farmer, the farmer's son, the farmer's wife, the professor of agriculture, and everybody except ourselves. There are many reasons why we have

so few students taking the course in agriculture. They could not be named in half an hour. This is a large question and that is the reason we have to discuss it over and over again. But as to the statement that agricultural colleges are not in sympathy with agriculture, I do not believe it is true and the interest manifested in this Association, year after year shows that it is not true. I believe there is not a man at the head of an agricultural college that is not deeply interested—certainly I am—in seeing the number of agricultural students increased. Each one believes that he is doing just about right now, but I question whether we in Indiana are. I hope that we can spend this afternoon or a good portion of it not in a discussion of ancient history, but in considering, for instance, whether Purdue is doing the right thing. Certainly we are not all doing the same thing, and if one man is doing just right, the others are not quite right. Take the curriculum of Purdue this afternoon and go for it. Knock it to pieces if you can.

While we do not have large numbers in our schools of agriculture, and while we may never expect to have a number equal to those taking the course in engineering, we must not be altogether cast down at that fact. If the students will not come to the colleges the colleges must go to the students. I believe that to be the function of the experiment station. It is a scheme of university extension. The experiment station gives instruction to the farmer by bulletins and by holding institutes, and in this way 20,000 farmers are educated under the direction of the Lafayette station. They seem to appreciate it very much and they doubtless receive large benefits. So every experiment station can go to the farmer as a college and school of agriculture in every county in its State.

We ought not to send out word that this body of college men say that the agricultural colleges are not in sympathy with agriculture. I do not think my friend means exactly that.

Mr. LEE. He certainly did not mean anything offensive, but he did want to call out a frank discussion.

Mr. CLUTE. One gentleman said that he hoped we would not discuss ancient history. It is, however, a fact that by reading ancient history we learn to solve the problems of to-day, and I am inclined to believe that a little ancient history would not be out of place now. The fact that we do not have enough students in agricultural colleges is due in many cases to the fact that the farmers and their wives and friends, from the time a child is born until he is 21 years of age, are continually dinning into his ears that farming is a poor profession. They tell the boy that the farmer works hard and gets small pay, and that he is the tool of politicians, and looked down upon by society. Now all that, constantly drilled into a boy, inevitably leads him to look upon farming as a profession that he should avoid. We have had young men come to us with no intention of becoming farmers because they had been taught that farming was an inferior profession; but four years' training

with our excellent equipment, library, and professors, have in many cases brought these young men, who came to us from the farm disgusted with farming and determined not to enter on farming as a profession, into a different attitude toward farming, and many have gone back home to buy farms and become intelligent, capable, and well-trained farmers.

There are social difficulties that must be considered. The farmer lad does not have the social culture which comes to those engaged in other occupations. This is one of the reasons why our schools of agriculture are not better attended. I think much of the criticism heaped upon agricultural colleges is a great error. If we train up men to teach chemistry in all the length and breadth of the land I claim that we are doing magnificent work.

One of the reasons why our schools of agriculture are not more widely acknowledged and attended is this: They are united with great universities having great departments of Latin, Greek, science, and engineering in its various branches, but only a little space for agriculture. The spirit of the institution is against the industrial course, and a young man going to that school is looked down upon by the rest of the students, and sometimes by the professors, for his grimy hands and coarse clothes. The result is that a young man is almost forced into other courses. The agricultural course will never succeed until you make it important and give it money and appliances.

Mr. HENRY. On the shelves of our agricultural grocery we have had the same things for the last twenty-five years. Our custom has passed away and we have a very small trade. Is that not so? Would it not be well now to look these goods over and study the demands of the trade, in order to see whether we may not better ourselves? Get the sort of goods that people want and you will call in custom.

We have in Wisconsin what we call a short course in agriculture, which I believe goes a long way toward meeting the wants of the people. How did we get it? The man who proposed it was Vilas. At a regents' meeting one of the members read the curriculum for the agricultural course by subjects, one after another, including "Æsthetics." Mr. Vilas followed with a speech remarking the subjects embraced in the agricultural course, one after another, until he reached this item. "Æsthetics?" said he, "Great God, gentlemen, Æsthetics!" From this speech resulted our short course.

This short agricultural course is strictly practical and has been fairly successful. We have also a course of twelve weeks in each of two winters. Why did we make the short course? Why did Mr. Vilas want it shorter? He taught in a law school and knew that a high standard of admission tended to keep out students.

I believe that our courses must be put down, down, down. In Minnesota, the school established by Pillsbury has done more than any other in getting the goods before the people that they want. Mr. Hall is here, and I hope that the college presidents will hear how Minnesota

has been able to get one hundred men each year. Let me tell you, my college-president friends and trustee friends, you have a great question. Was it the engineers, the manufacturers, who plead that more money should be given for education? It was the farmers, the agricultural papers and colleges. It was in the name of agriculture that the money was asked for. But where is there to-day a school where a boy who wants to learn about sheep can learn as much as he can from a shepherd? What professor of agriculture is there who knows half as much about horses as a horseman?

I think it is a shame that we have in our colleges only one professor for all agriculture. In a law college there may be a dozen professors of law, and in medical schools the same. When the colleges have professorships of horses, of cattle, of sheep, of pigs, they will attract the farmer. John's father will say, "John, we have a hundred sheep, and I think you had better go down to that professor and study about sheep. His whole time is given to sheep."

We have registered at our college over one hundred students for this term, and over sixty names entered for the dairy course. Why? Because it is practical. When boys can learn about sheep, pigs, and cows they will go to college, not before. Let us separate the professorship of agriculture into about a dozen parts.

Mr. ALVORD. On behalf of the executive committee, I wish to announce that the programme provides that the sections shall meet this afternoon and organize for work.

At 6:15 p. m. the meeting adjourned.

EVENING SESSION, TUESDAY, NOVEMBER 15, 1892.

The meeting was called to order by Mr. Alvord at 8:20 p. m.

Mr. Broun then delivered his address as president, as follows:

GENTLEMEN OF THE ASSOCIATION: In the annual address to be made on this occasion, in accordance with the custom and law of this Association of Agricultural Colleges and Experiment Stations, I propose to occupy a portion of your time in discussing the educational features of the institutions here represented and their adaptation to the wants of the people.

Education that looks to culture alone, while attractive and elevating in its nature and refining in its influence, does not of itself qualify the recipient for the active duties of life. It simply builds the piers of the bridge to be crossed. There must be superadded to this culture, when obtained by the fortunate possessor, that technical education which will span the chasm that separates college life from actual life.

Milton's definition of education, "that which fits a man to perform skillfully, magnanimously, and justly all the offices, both public and private, of peace and war," is of too general a character to be of value. For, whatever might have been thought possible in Milton's day, it is beyond doubt impossible now for any one person to be so equally well educated in all departments as to be able to perform skillfully all the offices of peace and war.

In former years the older college systems were especially adapted, with their excess of classical culture, to the professions of law, medicine, theology, and pedagogy.

But long since thoughtful men recognized the defect of a system of education that prepared the youth of the country only for the so-called learned professions.

The fact that of the many millions of our people who were engaged in gainful occupations, about one-half were employed in agriculture, and less than 3 per cent belonged to the class of lawyers, physicians, clergymen, and teachers, showed the necessity of broadening our educational system to include this larger class, for which but little special provision had been made. And, besides this, the changes wrought in the varied occupations of life, by the advances made in science and its many applications to the industrial arts, demanded that provision should be made for a wide diffusion among the people of a knowledge of these sciences and their applications.

It was in recognition of these facts that the Congress of the United States made the liberal donation of public lands to establish the American agricultural colleges.

It is gratifying to consider that wise provision of national legislation through the instrumentality of which there now exists in every State and Territory a college, endowed by the General Government, for the education and elevation of the people by instruction in the principles and applications of science. Our admiration for the far-seeing wisdom of its authors, who in that legislation "builded wiser than they knew," increases the more the subject is considered.

By the well-known act of Congress of July 2, 1862, by which the land-grant colleges were founded, Senator Morrill, of Vermont, built for himself a monument more lasting than brass; for thereby his name will be held throughout our entire country in affection and esteem by the youth of the centuries to come, who shall fill the halls of these colleges in seeking that education which shall fit them to become citizens worthy of the Republic.

It would, therefore, I beg just here to say, be eminently proper that there should be placed in the library of each of the land-grant colleges a bust of our distinguished legislative patron as an evidence of our high appreciation of the great work he has accomplished in the cause of education.

The historic period in which the act of Congress became a law suggests a somewhat parallel instance in the establishment of a celebrated European university.

The historian tells us that hardly had the sound of the Spanish artillery ceased to be heard across the plains of Holland when Leyden decked herself with flowers in honor of the founding of the great university which has for centuries cast the light of science and learning to the remote parts of the earth. While Leyden was founded as a memorial of peace, our colleges were founded in the hope of peace and the preservation of the Union.

Just thirty years ago, when all the energies of our country were being consumed in that terrible internecine struggle; when war, with its consuming blight, was alone the subject of thought and object of action; then, with a wise foresight rarely equaled, with a sublime faith in the future of our country, did Congress set apart and devote a vast portion of the public domain to the several States, in trust for the collegiate education of the generations to come. This act alone will signalize in history the Congress of 1862. A century must elapse before its beneficial effects on the education of the people will be duly appreciated.

As it was only possible once in the history of the world for America to have been discovered, so it was only possible once for the consecration of this large area of the public domain to the cause of education. And as the historian of the future traces the development of civilization in our Republic and investigates the causes which have contributed thereto, the legislation which established these national colleges of science and the arts will be classed as a prominent factor. This affirmation is based not so much on what has been done in the field of education by these institutions as on the promise of the future; on the broad view and purpose expressed in the charter, as given in the act of foundation; and on the fitness of the character of

education, designated as the leading object of the colleges, to the wants of the people and to the demands of the age of science in which we live.

At first many of the States, generally from economic considerations, associated these colleges with their State universities; others founded independent institutions. But in recent years the tendency has been in some States to dissociate and establish separate colleges, from a belief that thereby the object of the educational grant could be better accomplished. But whether they existed as coördinate parts of State universities or as independent institutions, one familiar with their history can not fail to have observed that in the early days there existed a widespread prejudice against the character of education proposed to be given. They were in many places regarded as inferior colleges for an inferior class. And possibly in some instances the mistake made in the organization and schedule of study may have furnished apparent cause for the existence of such prejudice.

The function of the college was without doubt often misunderstood, and misapprehension in the popular mind was due largely to the name the colleges bear. By many they were thought to be colleges established for the sole purpose of making farmers of their graduates, that they were professional schools established for the purpose of educating boys to be farmers, similar in that respect to the professional school for educating young men to be lawyers and physicians, and often the college experienced severe criticism if its graduates should prefer to adopt some other vocation. In the opinion of these critics a land-grant college failed of its object just in proportion as its graduates failed to adopt farming as a profession, and its success was considered proportionate to the number of farmers among the alumni.

This contracted view of the object of these colleges has now largely yielded to a more generous appreciation of the object of the grant; to a better understanding of the broad and comprehensive plan of the charter, as contained in the act of Congress; as well as to a more correct appreciation of the relation of technical to liberal education, and to the acknowledgment of the high privilege and right of an American boy to select his own vocation.

The leading object of our colleges is, as expressed in the original act, "to teach such branches of learning as are related to agriculture and the mechanic arts;" and while it also includes military science, it does not exclude classical studies. This is broad, comprehensive, wise, not narrow or contracted. The leading object is to teach the principles and the applications of science, to teach subjects that relate to the useful arts, and while culture, by the study of the classics, is not excluded, it is not the leading object. It were needless before this association to name the different branches that relate to agriculture or the many departments of exact science that relate to the mechanic arts. All these constitute the direct object of the instruction to be given.

In the first years of the history of these institutions attention was paid generally to agriculture and its branches, to the exclusion of the mechanic arts. This resulted not only from economical considerations and from the larger interests involved in agriculture, but also from the inability at that time to teach the elementary forms of mechanic arts as successfully as is now done in the modern method of manual training.

From an experience of eight years in an institution where a well-equipped laboratory of mechanic arts constitutes a part of its educational equipment, I can not express with too strong emphasis my appreciation of the beneficial effects of the modern method of teaching what is known as manual training. All present are familiar with its methods and the educational controversy in regard to its merits as a means of education. Some enthusiastic advocates have probably pressed its claim with too much ardor and demanded that it should occupy too exalted a position among the methods and subjects that are generally recognized as means of education. Be that as it may, its true value is now recognized by educators. It has come

to stay, and deserves recognition in the lower classes of a collegiate course, but only as a means of discipline.

Its object is not to make mechanics nor the making of things, but the making of men. Its methods develop order, accuracy, perseverance, and self-reliance, and while imparting manual skill and giving strength to the body its exercises tend, in a very marked degree, to develop the constructive and executive faculties.

Drawing, which gives the ability to express the concept graphically, is also an essential element of a scientific education, universally recognized to be of value. Hence a school of drawing as an adjunct to the school of mechanic arts is a necessary department of a land-grant college; and the manual training received from the series of graduated exercises given in this school, when combined with the study of science as practically taught in the different laboratories, gives an education eminently fitted for the American boy of the nineteenth century. Moreover, the wisdom of the charter of these colleges, in requiring that provision should be made for education in those branches that relate to mechanic arts, is made manifest when we consider their relation to the necessities of civilization.

The studies that relate thereto are studies that relate to active life. The arts by which raw material is converted into food, clothing, and shelter for civilized man, by which towns and cities are built, by which rivers are spanned and roads constructed, and by which manufacturing is rendered possible, these, and all that mark the progress of the present century, are directly or remotely dependent on the applications of mechanic arts.

The relation that technical education has to modern civilization and the benefits to be derived therefrom are apparent to all observant minds. Daily observations show the advantage of skilled and intelligent labor over that which is ignorant and unskilled, and make evident the important part that educated industry has in modern civilization. These facts clearly demonstrate that for a state to equip her youth by proper education for this industrial age, to plan wisely for the future, she must encourage and liberally support technical education.

In view, therefore, of the prominent position mechanic arts now occupy in many of the land-grant colleges and of necessity must occupy, it would seem eminently proper that this Association should also provide a department or section devoted to the consideration of subjects related thereto, where our colleagues in these departments may discuss methods and improvements for the benefit of all concerned.

The relation that technical education bears to liberal education is more generally appreciated now than formerly. In the early history of some of the colleges we represent it is probable that too much attention was paid to mere muscular education, not recognizing the fact that if energy is consumed too largely by muscular exertion there will be but little store for mental effort. There is no true education in drudgery, in mere muscular labor, when the brain is not exercised. Colleges were not founded to teach manual skill, but to teach brain skill, to develop mind and character. And merely learning how to do without learning the why is empirical, a rule of thumb method, which no educator can approve. In education, principle is far beyond practice, and a knowledge of principle is essential to good practice. Hence technical education to be of value must be founded on a knowledge of principles, on a liberal education; and the broader and more extended the base of liberal education which constitutes the foundation, the more symmetrical will be the column of technical education which forms the superstructure.

By the term liberal education as here used we do not necessarily include or exclude the classics. A fair knowledge of Latin is, for obvious reasons, of great advantage to a boy, and its prosecution is always advised if time and circumstances permit. But a comprehensive knowledge of the principles of science is essential to a liberal education and especially to that liberal education which is to constitute the foundation for successful technical instruction.

Education in the principles of science must be insisted on if we hope to attain success in instruction in technics. While this is true in every department, it is pre-eminently true if agriculture be the vocation for which the student is to be qualified. But the test of exact knowledge of the principles of science is the ability to put them in practice; hence the necessity of laboratories and workshops in every department of science in connection with our colleges. We have, or, if not, we must have, in each land-grant college laboratories of chemistry, physics, mechanic arts, botany, biology, and of other sciences, where students may learn things, not words; where they may learn to execute; may educate their brains through their hands: may learn science through their finger tips. But scientific laboratory work has its most comprehensive field in agriculture, in horticulture, and in the dairy, for here successful experimentation exacts tribute from almost every other department of science.

Successful instruction in agriculture demands both theory and practice, a knowledge of the principles of the sciences with which agriculture is directly concerned, and a knowledge of the methods of applying those principles to successful practice. Laboratory practice in the field, garden, and dairy is essential, but it should always be educative in character, should exercise the brain as well as the hand. While *why* we plow is best learned at college, *how* to plow is best learned on a farm.

But the function of the land-grant colleges is not solely to make farmers of their students, and where such an opinion prevails the public mind can not, for the interest of education, be too soon disabused of the impression. To attempt such a rôle must of necessity result in failure. Nine-tenths of the boys who attend colleges in the South, if not in other sections, find when they graduate that their capital on which to begin life is their education alone. On their brains and hands they must depend for success. They can not engage in farming without a farm, and this, as a rule, they do not possess; hence they must begin as wage-earners, as teachers, engineers, chemists, or in whatever capacity their education and environment render possible.

But, should favorable circumstances render it possible for the young graduate to begin life as a farmer, it does not necessarily follow that he will make a successful farmer. When the conditions of land and market are favorable success in farming comes of practical experience, close observation, and executive ability, with untiring energy and good common sense, qualities that no college that exists or may exist can impart. But yet a good science education, such as is given in our land-grant colleges, is the best possible preparatory training for success in this honorable vocation.

We maintain, therefore, that the function of the land-grant colleges is not to make farmers of its students (and in saying this we are simply repeating the well-known opinion of the legislative founder of these institutions), but to make men; men with educated brains and skilled hands, ready and willing to work with both brains and hands in whatever vocation they are best fitted to perform the duties of life.

There is another view, worthy of consideration, which necessitates a broad and liberal curriculum, as required in the act of Congress.

The freedom and possibilities of American life differ from the fixed relations of an older European civilization, where the son is expected to adopt the vocation of the father. American freedom protests against a system that would educate a class of boys for one vocation only. The right of an American boy to carve out his own fortune and to adopt any vocation that his inclination and talent may lead to and his judgment approve, should not be abridged by an educational system designed to prejudge his future and train him for one vocation only. He does not measure his possibilities by his father's attainments. He may be farmer or physician, teacher or lawyer, merchant or mechanic, preacher or president. Hence our agricultural colleges should not be modeled after the plan of the European. They of necessity must

be broader and more liberal in their educational schemes in order to adapt themselves to American civilization.

While these views are not new to the members of this Association, still they needs must be in many sections emphasized with insistence, in order to give a just impression of the educational work we are endeavoring to do and are required to do under the law establishing these institutions.

They constitute on the one hand the argument for breadth, for liberal education against narrowness, which is sometimes charged by adherents of the old classical culture, who contend that there is no place for an agricultural college in the American system of education; and on the other hand they furnish the argument for liberal education against the empirical technical instruction that even yet in many sections agricultural friends contend should be the limitations of the educational sphere of the land-grant colleges.

The growth of these institutions, their influence in causing older colleges to modify their courses of instruction, the high esteem in which they are held by men of learning as educational centers of power, the life and energy they manifest in every State, furnish an answer to each class of critics and give assurance of an influence for good that will widen with the years.

Our Association represents not agricultural colleges, but American agricultural colleges; broad institutions, adapted to American civilization, and not imitations of those which exist elsewhere and are adapted to an older civilization where class education is recognized. They are the product of our civilization and of the century in which we live and represent not the old, but the new education, and this so-called new education makes no protest against the old classical system, which has for centuries held the gateways of the temple of learning and trained, disciplined, and refined human thought and expression. It is not revolutionary, but supplementary, and seeks to build up and develop American civilization by making the leading object not linguistic culture, but scientific training.

Our colleges represent the legitimate outgrowth of the progress of science and the demands of the century. They must grow in harmonious development with the age in which they exist and must not cease to grow, for with a college the cessation of growth is the beginning of decay. Their faces are turned toward the future and not toward the past; hence their chief concern must be about the studies of the present and future.

In the former centuries it was not useful knowledge, but polite learning, not the laws of nature, but the laws of language, that were deemed worthy of study.

No one knew a century ago that steam would revolutionize the world and change the methods of human industry. No one knew that it would enable England with its limited area and population to do the work that represents the equivalent of the manual labor of all the able-bodied men of the world, but the fact is it has changed the face of the civilized world, entered every department of human industry, and largely modified our educational systems. It is then no longer a question whether science shall be taught or not. The spirit of the age demands it, and the question now is, in the limited time that can be devoted to education, how much of the old can be retained?

We have reason to be thankful that the colleges represented by this Association have their faces turned toward the future, and that there is established in every State of the Union a college that exalts *useful* knowledge and educates its youth for the future and not for the past.

But some contend, though at present the tendency is to a more liberal view, that education in science is inferior in character and in discipline to the old form of education of the classical colleges. Were this the proper place for controversy we might assume the aggressive and challenge comparison of the results of the centuries of educational work under the classical curriculum with the achievements of

the scientific schools of recent times. If fruits are the test of merit, the decision would not be doubtful.

In defense of the discipline that is the result of the study of science, we may briefly say that its study gives thought and tone to the mind, cultivates accuracy of perception, discrimination of judgment, closeness of observation, correctness of reasoning, and imparts a love of truth rather than of victory. And further, by its study of the concrete rather than of the abstract, by its constant looking for the relation of cause and effect, the mind is familiarized with the true spirit of inductive philosophy, the philosophy of daily life, and thus in its educational effect is demonstrated the truth of the definition that science at last is only "refined common sense."

Our contention is that the education given by the scientific and technical schools holds no inferior, but for many vocations, a superior rank. For it gives an educated man power in practical life, gives self-reliance and trains executive ability, gives true manhood, and looks to life in its wider aspect and not to self for culture's sake. Culture is a luxury for education, but science is a necessity, a necessity for all the people.

There is one feature of our colleges that in this brief review should not be omitted. The charter makes instruction in military tactics imperative, and to emphasize the obligation the general government has made provision to furnish to each institution a qualified officer to give the requisite instruction, and thereby we have the excellent instruction of the U. S. Military Academy extended to the thousands of young men of the several States who attend the colleges here represented.

The military instruction and training received makes of the young men citizens of more value to the State and the Nation. They constitute material for the trained military reserve, ready to support the arm of civil authority should occasion require, and hence are an element of power in our midst, which, increasing with the years, tends to conserve our civilization.

That military instruction is required is a mark of the wise legislation that formulated the charter, and fidelity to the trust requires that all its provisions should be faithfully executed. The report of the Commissioner of Education for 1889 shows that 54 per cent of the 10,000 students in the land-grant colleges received instruction in military tactics, a gratifying result, furnishing evidence that the trust is executed in accordance with its requirements.

But this Association represents not only agricultural colleges, but also the agricultural experiment stations connected therewith.

Experience confirmed what reflection anticipated, that agriculture neither as an art nor as a science could be largely promoted by teaching college students the elements of the sciences related thereto.

The agricultural colleges at first largely failed to win the confidence of the farmers, those whose interests they were especially designed to promote. They were criticised for not accomplishing an impossibility.

The unsolved problems of agriculture demand for their solution the profound study of the best scientific experts, and are to be solved only by accurate scientific investigation and experimentation continued through successive years.

The necessity for means and men to conduct this scientific research and investigation of the varied subjects related to agriculture was first recognized by college workers; and public opinion, largely created by their influence, was formulated by Congress in the act of 1887, establishing the agricultural experiment stations. By this act there was made by the general government a munificent endowment for research, and thereby has been established in every State a corps of scientific experts, whose duty is not to teach but to investigate, to investigate scientifically subjects that relate to agriculture.

No government ever before paid a higher tribute to the value of science or made a more valuable contribution to the interest of agriculture, on which all other depart-

ments of industry depend. Provision was made both for discovery and dissemination. This important supplement to the agricultural colleges has given to the farmers of every State a corps of scientific officers to work exclusively for their interest, and has wisely provided that the results of the investigations shall be brought home to them in the form of printed bulletins. The investigations have already borne fruit in the discovery of important truths and in the dissemination of knowledge of value to the farmers, and in the coming years benefits of inestimable value must accrue to agriculture.

The officers of the station have a great work before them—one worthy of the best labors of the best men. They have to call forth their best energies, not only the stimulus of devotion to science in the search for discovery, but also the satisfaction of knowing that what may be discovered of value to agriculture will cause its authors to be esteemed in the years to come as benefactors of the human race.

But the growth of these colleges during the quarter of a century of their existence and the progress of science demanded that they should be provided with enlarged and improved scientific equipment, with a larger staff of officers, with better libraries, and improved facilities of instruction. And the Congress of 1890, with marked unanimity, happily under the leadership of the distinguished author of the original bill founding these institutions, passed the act granting an additional endowment, increasing for specific purposes the income of each college.

By this last and third Congressional act, the colleges have a pledge of confidence on the part of the general government of which every incentive that ennobles human nature demands that they should prove themselves worthy.

There should be no steps backward. We must, as earnest Christian teachers, as true students of science, work continuously and earnestly, and execute faithfully the great trust committed for the present to our keeping. It is a great trust for the benefit of the people, all the people and not for any special class.

The admirable form of government under which we live is illustrated in the relation of these national schools of science to the States and the General Government. The colleges, though endowed by the general government, are subject only to State control under conditions imposed on the trust. These conditions inhibit the use for building purposes of the income from two of the grants and permit a small expenditure from the third.

Hence, in accepting the trust each State imposed on itself the obligation to provide for its college all buildings that are necessary to a full realization of the objects of the national grant. The reports show that this obligation has been complied with in a liberal manner, by large donations from the State legislatures and from other sources, the value of the gifts to these institutions in land, buildings, and equipment, being in excess of \$5,000,000. By this provision the interest of the State in the college is increased and the endowment is preserved undiminished. It is held by the States in trust, in perpetuity, and cannot be squandered or lost by mismanagement. Hence our colleges are permanent institutions resting on a foundation as secure as the Government itself.

From the last published report of the Commissioner of Education, for the year 1889, we find that the thirty-two land-grant colleges named therein had 700 officers of instruction, with nearly 10,000 students; that they enjoyed an annual income of \$1,500,000, with an endowment of \$10,000,000; that the value of their grounds and buildings was estimated at \$6,000,000, with a scientific equipment valued at nearly \$1,000,000.

And further, as significant of the growth of fourteen colleges there reported, in the five years from 1884 to 1889 the number of instructors had increased 30 per cent and the number of students 50 per cent.

It is true that several of the institutions given in this report are State universities, but were we able to present the reports of the fifty-three land-grant colleges established in 1892, limiting the statistics strictly to these colleges and the corresponding

departments in the universities, the figures given would not be diminished, but largely increased. Besides the colleges, this Association also represents fifty-one experiment stations, with a staff of over 500 officers and assistants scattered throughout the States and Territories, working for the promotion of the great interests of agriculture.

The number of students and officers of instruction and investigation, the value of the buildings and equipment, and the amount of the endowment and annual income demonstrate the importance of the trust committed to the officers and trustees of these institutions. They have long since passed the experimental stage and are now recognized as important factors in advancing education and promoting civilization in America.

Our duty is to make the work of these colleges and stations known to the world. And the opportunity presented in the World's Columbian Exposition at Chicago should be improved by presenting, in the most efficient manner, the methods used and the work done. Faithfulness to our trust, as well as the interest of the institutions we represent, demand this. But to make the exhibit worthy of the institutions will require a large additional expenditure of energy and money. That our governing boards are authorized to direct this expenditure, appears evident from the educational nature of a representative exhibit and the wide diffusion of useful knowledge that would result therefrom.

Especially does it follow that an appropriation of funds for this purpose is legitimate, since the diffusion of useful knowledge is named in the act of Congress as one of the objects of the grant. With means available and proper energy there can be made, and should be made such an exhibit at Chicago as will challenge the admiration of visitors, American and foreign; such as will show the beginnings of the great work to be accomplished by the national schools of science and the agricultural experiment stations for the education and upbuilding of our whole country.

In presenting to you these views I beg you to consider the relation you hold to the present and future well-being of our country. You are scientific investigators, working for the improvement and promotion of that industrial art which directly concerns the well-being of the largest portion of the human family. You are observing, noting, comparing the methods of nature's action, in order to discover what promotes or retards plant or animal life. And, whether working with retort, microscope, or pruning or dissecting knife, you are working to ameliorate the conditions of human life, and by showing how better to subdue the earth, to bring increased prosperity and happiness to the homes of the people, you are working not for self, but for the good of humanity.

We are teachers, having under our charge thousands of the youth of to-day, those upon whom the future destiny of our country will largely depend. Let us duly appreciate the magnitude and importance of the great trust committed to our care, its weighty responsibilities as well as its immense possibilities; let us faithfully and zealously execute its provisions, educating the youth entrusted to us so well and so thoroughly in the principles and applications of science that they will show in their lives that love of work, that love of truth that comes from an imbibition, by science study, of scientific method and scientific spirit; let us, looking to the future with an earnest love for our whole country, faithfully work to make the national schools of science here represented the best schools, best in their adaptation to the demands of American civilization, best in their harmony with the spirit of the age, and best in the wide diffusion of a patriotic and Christian spirit among the youth of our country.

Mr. Alvord distributed copies of the revised constitution as reported by the executive committee and announced that it would be considered at the morning session of the following day.

Mr. Curtis, for the program committee of the section on agriculture, announced the following program for the section on agriculture:

Wednesday (1) Details of successful farmer education; (2) What should the professor of agriculture teach?—G. E. Morrow and P. M. Harwood; (3) Soil investigation, E. W. Hilgard (prepared for the chemical section); (4) Relation of the experiment station to the agricultural college, for open discussion. Thursday (1) The field of bulletins, present and prospective, C. L. Ingersoll; (2) The establishment of official methods of experimentation, W. A. Henry and F. A. Gulley; (3) Mistakes to avoid in dairy experiments, H. H. Wing; (4) Forage-plant tests, their scope and plan, C. C. Georgeson.

Mr. Turner announced that the section on college work had requested Mr. Fairchild, of Kansas, to present to the general session a paper on the relation existing between technical and general courses of study, and moved that this paper be presented at once.

The motion was carried and Mr. Fairchild read as follows:

THE RELATION OF TECHNICAL TO GENERAL COURSES OF STUDY.

The methods of training for active life have varied from time to time with the ideas of the leaders among educators. The swinging pendulum of thought is found everywhere, and perhaps is nowhere more evident than in the effort to train to most usefulness in the least possible time.

The trend of earnest effort at all times toward special training is natural, for several reasons. It saves time in gaining a living. The specialist can pay his way from the start. Further, it makes haste towards usefulness. One who, saying, "This one thing I do," can do the least of useful things, seems doing well and fills a niche in somebody's plans.

The great advance in division of labor everywhere reveals the fact that such division is profitable, both to the actor and to the world for which he acts. The whole trend of civilization indicates that a little done repeatedly brings perfection in that little. And the whole mechanism of production and exchange tends toward economy in the little perfections. To seek some niche to fill, and fill it well, as speedily as possible, is the end which every youth has set before him in the practical lessons of life.

Moreover, the bulk of human knowledge in our day overwhelms the thoughtful youth and compels him at once to acknowledge the hopelessness of universal information. To expect, like Milton or Bacon, to compass all of science in one's education would be simply preposterous. A mere glance at elementary facts reveals the uselessness of such attempts. Even when one is exhorted to broaden his view of the world by extending his search into the grand humanities, the question instantly arises, which humanities? for every field of study calls for whole libraries and for almost numberless laboratories, with the ever present suggestion of more to follow. Thus the necessity for choice of culture is as evident now to the mere tyro in knowledge as it once was to the philosopher. Indeed the very general discipline of our youthful days through Roman classics and Greek poetry has now become a special training; and that which opened to the view of us elder thinkers a world and a history must now present to our children only the details of a few lives or must occupy a lifetime in searching for the ever-wavering influence of such thoughts in the world.

We must expect, then, the absolute necessity of special thought and special training for all who would maintain their part in this world of active thought. And yet

the dangers from attention to a single field of thought are the same now as ever. These dangers are both individual and social. To an individual mind occupied with a study of facts, however numerous those facts, the view of nature becomes narrow; occupied with few relations, the indefinite detail in those relations seems a universe—yes, even the universe—and other minds are read by the same little signs. The growth of reasoning power is thus limited almost to mere empiricism. The association of fact with fact in a single rut of thinking makes this one rut in the law of nature paramount among relations. Almost no estimate of truth is genuine, for such a mind, held within its narrow confines, so magnifies the nearer objects as to obscure their relation to the rest of nature. Such a view of our universe and its ever-increasing activity becomes shortsighted. Repetition after repetition of the same set of facts seems to make up both time and eternity, and instead of growth and expansion to meet the opening vistas of infinity the confine of the well-worn path occupies all energies. With such habitual views an overweening conceit is most natural and most frequently realized. Nothing so fully sets a man above his fellows, in his own opinion, as excessive familiarity with a few particulars indefinitely applied. The fact that such an individual often finds himself out of sympathy with his neighbors, misunderstanding them and misunderstood by them, too often only exalts his opinion of himself and makes even more exaggerated the tendency to narrowness, unreasonableness, unfairness, discouragement, and self-conceit. Such a result leads, naturally, to conflict in the social life of individuals. All mutual understanding between two persons implies, of course, a common place of thought. Two extreme specialists in different lines have no such common place, lack appreciation of one another's personality, and must fall back upon the simplest talk of weather and crops. A lack of common wants brings partisanship, and argument, for lack of common place and clearness of reasoning, becomes bickering and vituperation. Misrepresentation is inevitable, both as to abilities and needs; and too often the social world is all awry to the several eyes mistrained in observation of a single class of facts.

The world is full of examples. City and country vie with each other in furnishing expert instances, and the ignorance that is hardest to combat is the self-conscious knowledge of a narrow-minded routine worker with a single range of thought. These real dangers it is the part of true education to meet and destroy. No student of educational methods can be willing to be restricted to the laws of the one object of study he selects. His problem is to find a remedy for every evil tendency and yet lose none of the trend of nature in the growth of humanity toward its perfection of accomplishment.

The remedy of our earlier days for the narrowing tendency of technical training was to divide all growth between two periods: one of discipline, in which the range of knowledge is the mere gymnastic field for youthful energy of mind, and the other of training in the chosen profession through application of the wider range of particulars implied in discipline. This assigned all technical courses to a university where, by assumption, only disciplined minds were gathered. The long preliminary course of purely general knowledge was followed by a brief training in technical application. And yet the whole was far too slow in perfecting the work of the best minds and wholly inadequate in adaptation to growth from mediocrity into superiority. Too often the ardent earnestness of youth for accomplishment was wholly quenched, and multitudes became mere timeservers in vain speculation about the universe, while knowing nothing of the details of life and learning. The exhortation, not uncommon, to await developed powers before selecting applications for such powers, was quite like the ludicrous maxim, "Never go near the water 'till you have learned to swim." The actual swimmers in our earlier days in the seas of actual life were chiefly those whose necessities compelled daily application of ingenuity in details as a means of accomplishing discipline of mind in the general course of study.

The later remedy, and the better, for extremes in specialization, employs a unity of ideas, both special and general, concrete for the abstract and abstract in the concrete, embracing, if possible, all activities at once. This must recognize all knowledge sought in relation both to self and to humanity. "Truth for its own sake" means, in this connection, truth for its importance in the range of possibilities. Each step in advance is made upon the foundation laid in past activity. And yet the broader views of older students or of teachers are the constant stimulus to greater activity. All knowledge has its meaning with reference to some line of active expression, and that expression is its meaning in relation to all humanity. This implies that each student shall find by natural contact with the things about him the line of ingenuity which shall make him most useful to his fellow men. Instead of regarding his trade or his profession as simply a means of living, he naturally finds it a means of giving a larger life to his fellow men. Philanthropy is from the start a stimulus to exertion, because the active energy is made to illustrate the united interests of society, a nation or a world. With proper teaching the ingenious youth is led to find a blending of all sorts of relations through a great variety of studies adjusted here, there, and everywhere to his particular energy, and may grow continuously in breadth and in power. His world is an unlimited world, though self-centered, and he quickly outgrows the conceit of superior ability, by finding almost everywhere his need of equally important abilities in his neighbors.

I believe that the practical methods of training of our day may accomplish a truer growth than the extended courses of the past; but they must seek to do more than to simply perfect in dexterity and to foster the special ingenuity of students. It is possible in a course of four or five years in the common schools to embrace the essentials of a good education. It will lead to the arts of life and bring actual results, but will at the same time give those liberal views of human nature in the midst of outer nature which insure freedom of thought, clearheadedness, and practical wisdom. I would have such a course embrace the commonplaces of knowledge with actual service at each step in the common life of humanity.

To furnish the commonplaces, I would be sure, first, of accurate speech; and that because humanity needs it and each needs it to understand humanity. Second, such a system of reckoning as will cover all possible problems, but illustrated continually by the everyday problems of training. Third, systems of reasoning, inductive and deductive, not simply illustrative, but used in every phase of duty and accomplishment. Fourth, as complete an analysis of the universe as elementary statements and questionings can bring. Mathematically, the student should, as a friend of mine expresses it, see into space. Mechanically, he should test matter by all the senses and with many contrivances for producing and estimating mass and motion. Physically, he should experience force and comprehend conservation of energy at every turn. Chemically, he should experience order in the lines of his daily thought; the precision of manipulation should give him accurate conception of the universal law of atomic order. Organically, the world should touch him by enough of the animal and vegetable kingdoms in everyday surroundings to reveal the laws of growth, structure, and function in infinite variety. Intellectually, he should find himself the representative of all past experience, still reaching after a richer experience and to a fuller comprehension of the universe. Morally, he should find duty chief, and rights a consequence of rational effort to be of all possible use to fellow beings. This analysis does not require the history of thoughts about such problems, the pros and cons of controversy, or the quibbles of detail and description, but it requires ingenious application of the actual facts of daily life.

I would add as full an acquaintance with the world's experience—industrial, literary, and political—as will add to rather than detract from the interest in every day's experience. The very elements of knowledge embraced in the general range of the sciences can furnish suggestive materials, and well-stored libraries will arouse curiosity and incite to constant research.

All these commonplaces of knowledge may find their application in the so-called common life of humanity. The food supply, the shelter, and the mechanism of art touch every man's being and afford no end of illustration of the growth of knowledge and the power in wisdom. See to it that students have to do, by actual exertion, such parts of the world's tasks as concern most of the race. In this daily adjustment of tasks they may find that knowledge is not a garment worn for show, but their weapon of warfare against want, against weakness, or against brutishness, or their means for climbing to the summit of enjoyment.

Technical ingenuity, thus developed gradually among general ideas of usefulness in purpose, is not narrowing, but broadening, liberalizing, while it opens the way to perfection in the arts of life. It gives a real choice among pursuits that add to the welfare of the race, with less chance of bias from mere whim or curiosity. It builds character and power together.

Now a word as to details, and for these I can do no better than to outline in brief the plan pursued for the past dozen years at the Kansas State Agricultural College. An itemized statement of principles may suffice.

(1) Admit directly from the common country schools and if possible without a preparatory class. A college for the people must go to the people in its plans.

(2) Give as early as possible, with English and mathematics, an introduction to nature through drawing and botany, with mechanical training in simple construction applicable to every kind of life.

(3) With chemistry and mineralogy apply science in agriculture, horticulture, economic entomology, and household economy, with practice in all.

(4) With mathematical mechanics, agricultural chemistry, and physics, give a training in surveying—the basis for our title to our homes—and common engineering, suitable to all sorts of construction, exercising ingenuity in the same problems upon the farm and gardens, and in the shops for wood and iron work.

(5) Enlarge the scope by more general problems in thinking and reasoning, illustrated still by everyday facts in plant life, animal life, geology, and history and social economy, with technical trial in the arts of construction and production.

(6) Keep students thinking all along the line of the industries which employ the race and give our civilization.

(7) Make the faculty a unit in their sympathy with the purpose and methods of the college in training for the various pursuits of life.

(8) Interest the body of students in the object sought, and arouse a pride in their own institution as a foster mother in the useful arts, showing results worthy the praise of the people.

(9) Bring the college work to the people by institutes, by lectures, and by every means of direct contact between faculty and patrons, with especial care to bring to the front, in interest and useful effort, the graduates and former students whose good work and growth are proof of accomplishment of the grand purpose of the college.

(10) Cultivate the interest of absent alumni in the growth and advancement of their alma mater.

Mr. FERNALD. I am not quite willing to admit that the efforts along the line of agriculture have been unsuccessful. There are different methods of judging success. In the State which I represent there is great interest. There were 1,200 visitors—farmers, their wives, sons, and daughters—on our campus on the 15th of last June, and they went away friends of the institution.

Even though the majority of students do pursue the engineering courses, I do not believe that we are not accomplishing the purposes of the act of Congress. The State of Maine is fast becoming a manufacturing State, and we may be performing our duty, even though

not so many as we would desire follow courses of agriculture and become farmers. The point I wish to make is that we can not, under the law, conduct only the branches relating to agriculture and shut out the mechanical branches.

The question remains how can we induce a reasonable number to study agriculture? I think there is great difficulty in doing this. I do not say it is essential that we do this, but in view of the demand that exists in all of our States that we turn out more farmers, I am anxious to know how it can be done. I want to know how, when the different courses are put side by side and young men are allowed to choose for themselves, we can induce them to take the agricultural course in preference to others. According to my observation, the tendency is the other way. Can a remedy be recommended by this Association.

Mr. TURNER. This question suggested itself to me when reading the reports of the different colleges. It is a very important question for the institution which I represent. We are just establishing a department of mechanic arts and for the first time have a separate course in agriculture, but the difficulty that Prof. Fernald refers to has already suggested itself to me: how can we make the agricultural course attractive to students? It seems to me that the intent of this law is to give students a liberal education, including the branches of learning that underlie the art of agriculture, and not simply the practice of it. In order to attract students to the agricultural course must we abandon the sciences which underlie agriculture and teach only empirical science? It seems to me that that is the question.

Mr. JOHNSON, of Connecticut. My theory has been, and my practice is, to have a fundamental course which underlies both agriculture and the mechanic arts. Our course does not separate the two. We have instruction in greenhouses, laboratories, shops, and barns for all young men who take agriculture, horticulture, shop training, and mechanic arts as a basis for growth. In the last year only do we allow any departure from this, but we provide in the post graduate courses for special training along the lines developed before. We have not as yet found the least thinning down, though our State is rapidly developing in manufactures.

Mr. CURTIS. The agricultural section has on its programme a paper from Prof. Harwood on this very subject, and I suggest that further discussion on this matter be postponed until after the reading of that paper.

On motion of Mr. Alvord the meeting adjourned at 10:15 p. m.

MORNING SESSION, WEDNESDAY, NOVEMBER 16, 1892.

The meeting was called to order at 9:20 a. m.

Mr. Alvord submitted the new draft of the constitution prepared by the executive committee.

The PRESIDENT. The report before you is a substitute for the present constitution and will be read by the secretary by articles.

The secretary then read the first article :

I.—NAME.

This Association shall be called the Association of American Agricultural Colleges and Experiment Stations.

The PRESIDENT. If no amendment is proposed we will pass on.

The secretary then read the second article :

II.—OBJECT.

The object of this Association shall be the consideration and discussion of all questions pertaining to the successful progress and administration of the colleges and stations included in the Association, and to secure to that end mutual coöperation.

The PRESIDENT. The secretary will read the third article, if there is no objection.

The secretary read the third article:

III.—MEMBERSHIP.

(1) Every college established under the act of Congress approved July 2, 1862, or receiving the benefits of the act of Congress approved August 30, 1890, and every agricultural experiment station established under State or Congressional authority, the Bureau of Education of the Department of the Interior, the Department of Agriculture, and the Office of Experiment Stations of the last-named Department, shall be eligible to membership in this Association.

(2) Any institution a member of the Association in full standing may send any number of delegates to the meetings of the Association, but one shall be designated to the Association as the regular representative and voting delegate. The same delegate may represent both a college and a station, but shall cast only one vote in general sessions. Other delegates may be designated by any institution to represent it in specified sections of the Association, but such delegates shall vote only in such sections, and no institution shall be allowed more than one vote in any sectional meeting.

(3) Delegates from other institutions engaged in educational or experimental work in the interest of agriculture may, by a majority vote, be admitted to conventions of the Association, with all privileges except the right to vote.

(4) In like manner, any person engaged or directly interested in agriculture, who shall attend any convention of this Association, may be admitted to similar privileges.

Mr. HADLEY. I rise to ask for an explanation. In section 2 I read, "The same delegate may represent both a college and a station, but shall cast only one vote in general sessions." Does that mean that an institution having a delegate from the college and one from the station will have two votes, and that an institution having but one representative for both college and station will have but one vote?

Mr. ALVORD. That is the intention. The longest discussion at any convention of this Association, in my recollection, was upon that point, and the rule as it stands was settled finally by a large vote. The com-

mittee did not feel disposed to interfere with that decision of the Association made three years ago.

Mr. HADLEY. An institution situated near the place of the convention is likely to have two representatives, and therefore two votes; but an institution very far away from the place of meeting may be able to send but one delegate to represent both the college and station, and will therefore have but one vote. Is this fair?

Mr. ALVORD. I do not wish to reopen the discussion of three years ago, but in a very few words I can give some of the reasons which led to this rule. First, it was thought best to keep the proxy system in any form out of the constitution. Second, it was hoped that the rule might induce the various colleges and stations to send a full representation.

The PRESIDENT. There must be some motion made to make a change.

Mr. TURNER. I move to substitute for the clause "only one vote in general sessions" the clause "a vote for each institution."

Mr. HADLEY. I second that motion.

Mr. NICKERSON. I suppose the words should be permissive and not mandatory.

Mr. WOODS. There has never been a time in the history of the Association in which any matter, however important, has ever called out all the votes. If we extend the right of suffrage to two institutions represented by one member, shall we not be obliged to extend it to the institutions not represented at all?

Mr. FERNALD. Another point to be considered is that this Association meets in different parts of the country, so that the proximity of different institutions will about even up, year after year. I think the provision should remain as it is.

Mr. HADLEY. I suggest this form for the amendment: "And may cast one vote for each institution in general session by him represented."

Mr. HUNNICUTT. I suggest that it read in this way: "The same delegate may represent both college and station by vote in the general session."

Mr. SCOVELL. I think the provision is better as it is because it gives us a larger attendance at the meetings. I am inclined to believe that many boards of control would send but one delegate if he could represent both the college and station in voting.

Mr. FREAR. I think it desirable to enforce that point. I know personally of many institutions which would be represented if only the wishes and judgment of the officers in charge were acceded to. Sometimes those who hold the purse strings are not in accord with the officers of the stations, and unless pressure from the outside is brought to bear will rely upon their own judgment rather than upon that of the officers of the station. It seems to me that the clause should stand as it is.

Mr. ARMSBY. While I am in favor of the provision as it stands, it occurs to me that it might be subjected to a slight modification. The clause as it stands and the whole practice of the Association recognize the stations and colleges as in a sense distinct institutions, on account of the different character of the work undertaken by them. It seems to me right that if an institution, either a college or station, is not sufficiently interested in the work of the Association to bear the expenses of sending a delegate, it is not entitled to a vote in the convention. If this phrase is modified, I would suggest that it be made to read "that no delegate may represent more than one institution," meaning by institution either college or station.

Mr. HADLEY. I wish to say one word in the matter of illiberality. Some of you are probably not aware that every time a meeting of this Association is held it costs New Mexico from \$200 to \$300 to send a delegate. Last year we sent two delegates to the convention. So you see it is a matter of money, but hardly a matter of illiberality.

Mr. ATHERTON. I recognize the force which the point made by Mr. Hadley must have from his point of view, but in the majority of institutions which belong to the Association it does not apply. It seems to me that it would not be well, in the present condition of the Association, when it is wielding such a power among the institutions, and from the outlook promises to wield still more, to jeopardize its strength by changing the constitution so as to lessen the attendance at the meetings. I hope therefore the section will stand as reported by the committee.

The PRESIDENT. I will put the motion to vote. The motion is lost. Is there any other amendment to article 3? If not the secretary will read the next article.

The secretary then read the fourth article:

IV.—SECTIONS.

(1) The Association shall be organized into sections upon (1) college work, (2) agriculture and chemistry, (3) horticulture and botany, (4) entomology. The executive committee shall, upon the request of any ten institutions represented in the Association, provide for the organization of provisional sections at any convention.

(2) Each section shall conduct its own proceedings and shall keep record of the same, and present a synopsis thereof to the Association at the close of every convention; and no action of a section, by resolution or otherwise, shall be valid until the same shall have been ratified by the Association in general session.

Mr. PATTERSON, of Kentucky. I think we ought to add to the sections one on the mechanic arts. These colleges by the terms of the law are mechanical as well as agricultural, but the mechanical side, so far as I am aware, has never found recognition in this Association. In many of the land-grant colleges a department of mechanic arts is well organized, well manned, and should be recognized by this Association. I hold that it was the purpose of the act of 1862 to educate skilled artisans as well as scientific agriculturists.

The trend of capital is toward the towns. Of the great number of millionaires found by the last census, I suppose that nine out of ten live in towns. The tendency is toward the vast accumulation of wealth in the cities, and the trend of population in the same direction is equally strong. In 1790 it was estimated that the ratio of rural to urban population was 30 to 1; and now it is 4 to 1. You will all agree with me that a large part of the population of the towns live from hand to mouth. The mechanics, artisans, and skilled laborers constitute the explosive element of the country. It is easy to see that in the not distant future this will be a danger to republican institutions. I hold that it is the business and the bounden duty of this Association to make abundant provision for the education of mechanics and skilled artisans. Teach them their responsibilities, duties, and rights. How can that be done more effectually than by providing in the land-grant colleges for the liberal education of the industrial classes? I move you that a section of mechanic arts be provided for.

Mr. ALVORD. Mr. President, I hope that this motion will not prevail, and for this reason: In spite of repeated invitations to take part in this Association, the professors of mechanic arts instead of joining with us have endeavored to start an organization in a measure rival to this one. The constitution provides for additional sections, and if professors of mechanic arts come here and ask that a section be organized, it will certainly not be refused them; on the contrary, as past action shows, they will be heartily welcomed and granted the same courtesies and opportunities given to other specialists.

Mr. SCOTT. I desire to support the proposed amendment on the very ground on which the chairman of the executive committee has made his argument. We have just been exerting pressure on these institutions to bring representatives here, and certainly we should do more than to invite them. While I would not abate one jot or tittle of our interest in agriculture, I think the name that we bear is a misnomer, and we should follow as closely as we can the organic act which is for the benefit of agriculture and the mechanic arts. It may be that the gentlemen representing the mechanic arts feel hurt because we have given to agriculture an improper prominence. It certainly can do no harm and it may do good to adopt the suggestion of my friend from Kentucky.

Mr. DABNEY. I also desire to support the motion of President Patterson. I know from a conversation with the gentlemen who want to establish a section on the mechanic arts that they proposed to establish a separate association because they felt that they were not wanted here. I was somewhat disappointed and even pained to hear some gentlemen last evening express the opinion that the agricultural colleges were even in a measure a failure. I had hoped that our institutions had taken the broader view of the act of 1862, the view so admi-

rably expressed in the address of the president of this Association. I believe that as long as we take the narrow view that these institutions are nothing more than professional schools of agriculture we shall never satisfy the people. I am thoroughly convinced of this. The law did not intend to establish merely agricultural colleges. Our name is, therefore, a misnomer, and our constitution is one-sided. At the best, this constitution fails to represent properly two-thirds of our institutions. A large majority have mechanical departments, and a great many have extensive literary departments, including classics, modern languages, etc., which are in no way interested in the work of this Association. So we have been working with hardly one-half of the interests involved represented, and I sincerely believe that the time is coming when we shall make this Association influential throughout the country. How can we do that except by bringing in interests of every kind. Let us begin by bringing in men interested in engineering, later on those interested in other sciences, and, if possible, literary men, as work is provided in the classics and not merely economic science. There is no reason why in time we should not have sections of interest to men in all classes.

I would like to ask President Patterson to have this section include civil and mining engineering as well, because nearly all institutions have these departments.

Mr. HADLEY. I suggest that the motion should include a change in the name of the Association. Why not have it read American Colleges and Experiment Stations, or American Agricultural and Mechanical Colleges.

The PRESIDENT. Gentlemen should address themselves to the motion. The motion before the house is to insert in article 4 a fifth section devoted to mechanic arts.

Mr. HUNT. This is very interesting and I dislike to interfere in the general discussion, but a meeting of the section on agriculture is called for 10 o'clock, and at 10 o'clock I propose to move that we adjourn.

Mr. NEILSON. I think it is eminently proper that we should recognize the mechanic arts. The appropriations for the colleges are equally for agriculture and the mechanic arts, and it seems to me therefore but fair that we should recognize mechanic arts in this association.

Calls for the question.

Mr. DEPASS. What I wanted to say has already been said. Only this I will add, that the very caption is in my judgment wrong.

The PRESIDENT. I must confine you to the motion.

Mr. DEPASS. I wish only to call the attention of the Chair to the fact that I intend to make a motion on this question and will not detain the Association at this point.

The motion was carried.

Mr. WOODS. The hour for adjournment, in accordance with the rules, having arrived, I move you that we do now adjourn.

Mr. ALVORD. I simply wish to say that it will be impossible to bring this question before the convention again. I would cheerfully move to adjourn in ten minutes.

Mr. Woods withdrew his motion.

The PRESIDENT. If there is no objection we will pass on to the next, Article v.

The secretary read Article v.

V.—MEETINGS.

(1) This Association shall hold at least one meeting in every calendar year, to be designated as the annual convention of the Association. Special meetings may be held at other times upon the call of the executive committee, for purposes to be specified in the call.

(2) The annual convention of the Association shall comprise general sessions and meetings of the sections, and provision shall be made therefor in the program. The sections' meetings may be simultaneous or otherwise, at the discretion of the executive committee, but at least two sections of the Association, to be designated each year by the executive committee, shall present in general session of each convention a portion of the subjects coming before them.

The PRESIDENT. If there is no objection we will pass on to Article VI.

The secretary read Article VI.

VI.—OFFICERS.

(1) The general officers of this Association shall be a president, five vice-presidents, a bibliographer, and a secretary, who shall also be treasurer. The president, junior ex-president, the secretary, and four persons to be chosen by the Association shall constitute an executive committee, which shall elect its own chairman.

(2) Each section shall, by ballot, nominate to the Association in general session, for its action, a chairman and a secretary for such section.

(3) Officers shall be chosen by ballot at the annual convention of the Association, and shall hold office from the close of the convention at which they are elected until their successors shall be chosen.

(4) Any person being an accredited delegate to an annual meeting of the Association or an officer of an institution which is a member of the Association in full standing at the time of the election shall be eligible to office.

Several asked what would be the duties of the bibliographer.

Mr. ALVORD. He is to keep watch on the literary world in which this association is interested, and furnish bulletins calling attention to books or articles of interest to those connected with this association. We have an offer to publish these bulletins in the magazine, *Agricultural Science*.

Mr. TURNER. I wish to know whether the bibliographer is to be a salaried officer.

Mr. ALVORD. The officers of the association have equal salaries.

No changes were proposed to Articles VII, VIII, or IX, which were read in order.

Mr. DABNEY. I move that we reconsider the action by which the title was adopted.

The motion was carried.

Mr. DABNEY. I move that the name of the Association be changed so as to read The Association of American Agricultural and Mechanical Colleges and Experiment Stations.

Mr. SMART. I move to amend the proposed title to read The Association of National Colleges and Experiment Stations.

Mr. DEPASS. I move that we lay that amendment on the table.

Mr. SMART. I would like to say that it strikes me that National is a wiser term than American.

Mr. DEPASS. I withdraw my motion.

Mr. HADLEY. Does not national include all kinds of colleges organized under acts of Congress? Are they not national institutions?

Mr. DABNEY. Would this not include West Point and other colleges of that sort? They are all supported by appropriation.

Mr. ALVORD. I suppose this motion will pass, but I want to call attention to the fact that to change the name of a child when it is just becoming known is of no advantage to it. A single word more. This name was adopted after a full discussion. When you say agricultural college everybody knows what you mean. In the public journals the institutions here represented are known collectively as "agricultural colleges."

Mr. HADLEY. If the name is to be changed at all I do not like the term mechanical. Wherever I hear that term it seems to lack euphony. If the name be changed, I suggest Association of American Colleges of Agriculture and the Mechanic Arts.

Mr. SCOTT. I think that the closer we keep to the organic act the better. The act said "for the benefit of agriculture and the mechanic arts;" the whole system has been built up on that. We do not like the word mechanical. I certainly do not like the motion proposed that the colleges be called national. Our institutions are established under State authority. They are American, not national.

Mr. NEILSON. I agree with Dr. Scott. I think this question involves more than a mere name. We have had difficulties in New Jersey and I think probably throughout the country from misapprehension as to the scope of our work. I think the proposed change of name will have a good effect. It is not changing the name of the child, for all know it now by the proposed name.

Mr. Smart withdrew his motion.

Mr. SCOVELL. Mr. Chairman, I hope that the name will not be changed. I have a great deal of correspondence with colleges and treasurers of colleges and I have been advised by several that there would be no difficulty in getting dues if our name were shortened. I do not wish to inflict on my successor any more name to sign to vouch-

ers. Our Association is becoming known under this name, and I hope, for the sake of the Association and for the sake of members we have, that it will not be changed.

Mr. DABNEY. The motion is that the title shall read American Colleges of Agriculture and Mechanic Arts and Experiment Stations. I think the old name has caused much trouble and has retarded the progress and development of the college.

Mr. RYNERSON. I was in favor of the motion adopted providing for a section on mechanic arts, but I can not see any advantage to be derived from changing the name of the Association.

Mr. CAVITT. There seems to be something in the name of an institution. Why did Congress put "Agriculture and Mechanic Arts" in the bill? Was it not that both industries should be benefited? We represent mainly the agricultural department of these institutions, but I think we should be liberal enough to extend to the mechanic arts the honor of mention in the title. I am opposed to changing the name from American to National. I am a believer in reciprocity. Let us extend the hand of fellowship to South America, Central America, and Canada.

The motion was lost. Ayes 23, noes 37.

Mr. MYERS. I move that we now adopt the constitution as a whole.

Mr. ALVORD. I will ask unanimous consent for a verbal amendment. After the word agriculture in section 3, Article III, add the words, "Or mechanic arts," and the same in section 4.

The constitution was then adopted as a whole.

Mr. ALVORD. Carriages will be waiting for us at the St. Charles Hotel at 1 o'clock this afternoon to visit the Sugar Experiment Station at Audubon Park and the Southern University on the return trip.

Mr. Buchanan, representative of the Jefferson Club, was introduced, and stated that he was instructed to extend to the members of the convention the privileges of the club during their stay in the city. The invitation was accepted.

The convention adjourned at 10.40 a. m.

EVENING SESSION, NOVEMBER 16, 1892.

The meeting was called to order at 8 p. m.

The following resolutions were reported from the executive committee:

Resolved, That a committee of nine persons be appointed by the chair, to consist of members of governing boards of colleges and stations, to act as an advisory board in connection with the standing committees of this Association upon the coöperative exhibit of the colleges and stations at the World's Columbian Exposition.

Resolved, That the portions of the annual address to the Association by President Broun, which relate to the Exposition of 1893, be referred to this advisory board for its consideration and action.

The resolutions were adopted.

Mr. Neale, of Delaware, offered the following resolution.

Whereas this Association has received a request from the authorities of the World's Columbian Exposition to nominate four persons to be appointed members of the committee to supervise the tests of dairy cows during the Exposition at Chicago; and whereas this is a subject of such importance as to require the most careful consideration, with a view to appropriate action: Therefore,

Resolved, That a committee of five be appointed by the Chair to consider this subject and to report to this convention the names of four persons suitable for members of the said testing committee, and to also report what further action is advisable in the premises.

Mr. Alvord explained that this resolution had already received the consideration and approval of the executive committee and that he was authorized to report it back to the Association for consideration in general session.

The resolution was adopted, and Messrs. Neale of Delaware, Atherton, Myers, Henry, and Gulley were appointed to consider the subject and nominate the supervising committee.

It was decided to reverse the order of the evening as printed and call first the discussion on Numbering Station Publications.

The PRESIDENT. The discussion of the evening was to have been opened by Director Harris, of the U. S. Department of Agriculture. As Director Harris is not present I will call the next speaker, Prof. Henry, of Wisconsin.

Mr. HENRY. This matter was brought before the executive committee, I believe, through letters asking whether station publications could not be made more uniform in numbering. I wish to direct attention to that point at this time. I need not tell you, who have to do with getting together the sheets from our stations, that they are very irregular in size; that, further, some are numbered regularly and that others are indicated by letters and numbers. This works serious detriment to persons trying to keep track of them. I think that if we could stop a moment we would get straight. The farmer don't care whether the bulletin he is getting is a special bulletin C or bulletin 713. He will throw away nine out of ten after reading. But when I have just received bulletin 93 and find I have already had bulletin X, I am in confusion. Has bulletin Z been issued? If so, where is bulletin A? I have a complete set up to 99. Shall I file lettered bulletins with them? Again, one station issues fractional bulletins. Now $17\frac{1}{2}$ is received. Will $17\frac{3}{4}$ or 18 be the next one?

Now if we bear this point in mind I think it will be easy to solve the question. The farmer don't care about the number; the person keeping a file does care. Let us have this in mind when we do it. We want to have in the station library a history of the doings of our stations numbered consecutively. A simple numbering would have saved me perhaps a week's work, and in the next ten years perhaps two or three months' work trying to track out these sheets.

How shall we bind it? Why not issue bulletins in pamphlet form of the same size. Again, a number of bulletins have been exhausted and reprints made of them. One station has already republished five bulletins numbered for publishing a single bulletin. It has occurred to me that in Wisconsin we have failed to have the stations get bulletin No. 2. Why could we not, if we could not afford the expense of having type set up, have mimeograph copies made of them and send a copy to each of the stations? Of course it is better printed if we have the money. Now, we will help you in getting a set of the publications of our station.

I think, Mr. Chairman, it would be well to have a committee appointed to look over the subject pretty carefully in regard to this matter and make some report if possible. I feel that we are wasting too much time on small things, and to bring the matter before the Association I move that a committee of three be appointed by the chair. I see Director Harris is here and I will give up the floor.

Mr. HARRIS. It is not my purpose to enter into any extended discussion in regard to the publications of the experiment stations, but to confine myself to a narrow question in which it seems to me easy to work a great improvement without making great changes.

The Office of Experiment Stations is making elaborate and costly efforts to abstract, arrange, and index the publications of the stations. Much of this work for its highest value requires that the stations and many of the workers shall possess complete sets of station publications, and that these sets be so arranged that any publication and any place in any publication may be found readily, easily, and surely. Unfortunately peculiarities in the methods now used by the stations for naming and numbering publications make this extremely difficult. Two-thirds of the stations number their bulletins consecutively, using the natural numbers. The first bulletin published is numbered 1, and the twentieth, 20, the bulletin next before the twentieth, 19, and the one next after it, 21. This method has many advantages. For instance, when I take bulletin 20 of a station numbering in this way, I know that it has printed at least nineteen other bulletins. I know that these are earlier than this bulletin. I know that it has published only nineteen earlier than this bulletin. If I wish to refer to the tenth I need say bulletin 10 and no more.

These stations, as a rule, publish in addition to their bulletins an annual report, and it is customary for them to print one annual report in each and every year. Thus each year's publications consist of four or more bulletins and an annual report. One-third of the stations depart from this simple method. It will be sufficient to enumerate a few of the peculiarities. Some stations count the annual report as a bulletin. This raises the question, shall we say that the station has printed seven bulletins and an annual report, or six bulletins and an annual report, or seven bulletins and no annual report; or shall we

say, clumsily, as I suppose we must, that the station has printed seven bulletins of which one is the annual report? It is at least a cumbersome marking for a bound volume. Sometimes the annual report is printed as a part of the annual report of the board of agriculture of the State, and not printed separately. "Special" bulletins are in some cases lettered instead of being numbered, so that bulletin 20 is to be followed by bulletin Q, and the lists will read bulletins 11, 12, F, G, 13, H, I, 14, 15, 16, J, K, L, etc. This is bad enough at present, but what will happen when Z has been printed? Again, regular bulletins are both numbered and lettered, and we have 81*a*, 81*b*, and 82. Sometimes publications are arranged in volumes, the numbers beginning anew with each volume. Occasionally a bulletin is numbered with a fractional number. In only too many cases we have one or more series. Doubtless these peculiarities are often convenient to those who understand them, but to the caretakers in the many libraries in which these publications are preserved, to the students who use them and to bibliographers, that is, to all who care anything about the numbering of publications, these peculiarities must prove a weariness of the flesh. It seems to me that fairness to each other and to the public interest demands that we sacrifice personal and local convenience to the general good. In passing it is well to remember that to the farmer this question of numbering has little interest, his attention being confined to the contents of the bulletin.

In conclusion I wish to present the following resolutions which I will ask the secretary to read.

The Secretary read as follows:

Resolved, That it is the sense of this convention that, in so far as possible, the publications of the colleges and stations represented in this Association should be named, numbered, and dated according to an uniform method.

Resolved, That a committee of five be appointed by the chair to devise a system to be reported if possible to this convention for its action, or if not, to the executive committee, who shall then distribute copies of the plan to the institutions entitled to membership in the Association.

The PRESIDENT. Under the rules these resolutions will be referred to the executive committee.

Mr. NEILSON. I would like to say a word about the lettering of bulletins. Our station has been in the habit of lettering bulletins for this reason. For instance, a special interest is manifested in a bulletin. With us the cranberry interest has occasionally been the object of a bulletin. Now, we do not want to send to all a bulletin which affects the cranberry growers only. Now, if the bulletin is sent to cranberry growers only and it is regularly numbered, when the next bulletin is issued farmers from all over the state will begin to write asking why they were passed over in the distribution of that bulletin.

Mr. JOHNSON, of Wyoming. I favor this movement, and I want to speak of the method we have adopted in our station. Our bulletins are

numbered—our annual reports are not. When we print our bulletins, we lay aside a thousand copies for binding with the annual report at the end of the year. This binding together we find very convenient for reference and not costly, as the expense is only that of paper and presswork. I should like to see such a plan adopted by all the stations.

Mr. JOHNSON, of Connecticut. My station some time ago had occasion to issue a bulletin on the modification of the Kjeldahl method of determining nitrogen, of interest to chemists only. This bulletin was numbered in the regular order 112, and bulletin 113, one of general interest, contained a statement on the title page to the effect that bulletin 112 was of interest to agricultural chemists only and had been distributed among station workers alone. It was only necessary to issue a small edition of that bulletin, so that it was a great saving of expense.

There are some other points I wish to call attention to if in order. I have lost a good deal of time and have been worried and vexed in attempting to file the publications of the experiment stations. It is very important to my mind that each station should distinctly announce in print upon the bulletins the system which it follows in so far as it is peculiar. At the Connecticut station we issue our bulletins numbered consecutively from the beginning and ever since we have had funds to do it we have printed them in uniform octavo style. Some of our earlier bulletins were gotten up in any kind of shape that we could manage because we run the station three months without any funds and were always in arrears and always trying to accomplish a modest amount of work on a very, very limited amount of money so that our earlier bulletins were all sorts and sizes, some printed by sending the manuscript to an agricultural paper and getting proofs which were furnished us at the cost of press work. Any expedient to get material into shape and distribute it. Ever since we have been able to do so, since we have been getting \$8,000 per year to work with, we print our bulletins in good shape, in a legible form and endeavor to make them pleasant to the eye. We have always followed the plan of printing an annual report and including in it everything worth publishing. Our bulletins may be lost. Notwithstanding, our annual reports contain everything worth preserving. It is of great advantage to us also in that it enables us to revise our work, to reëdit it and present it in its most attractive form. The stations ought to furnish every facility, so that the student can readily master the contents of publications. There should be an index of the bulletin on the front page, so that he may see at once what is of the most importance to him. If I get a bulletin of ten, fifteen, or twenty pages and have to spend ten or fifteen minutes in finding out what is in it, I am disposed to lay it aside and take it up when I have leisure, which I never have, and the contents of that bulletin pass, as far as I am concerned, into oblivion, and can only be rescued by the

valuable endeavors of the Office of Experiment Stations. If that furnishes me a suitable index of this literature I may make it available. The amount of matter published in this country and in foreign countries is so immense that without every facility placed at the disposal of the student it becomes simply impossible to keep track of them. It is of the utmost importance that every single paper have a special table of contents, unless matter of simple sort, for without that it is difficult to take advantage of the information, however valuable, which is published.

Mr. REDDING. I rise to insist upon some of the changes in numbering bulletins which I have offered. I have adopted the plan of filing away not less than two hundred copies of each bulletin. So far I have included two years in one volume for the reason that the publications have not been voluminous. At the end of this period I have an index prepared to the volume and sent to the printer for binding. I send a copy to the director of each station, and, I think, to each college also. I find that it is of great advantage to me to have the bulletins bound in that way, and I believe it would be to others. I would be glad indeed if I could get bound volumes of the publications of each station. It seems to me that the stations would appreciate the work of other stations better in that form.

Now another point. In order to prevent our correspondents from calling for bulletins which we did not intend them to have I used the simple expedient of half numbers. A special bulletin I called $17\frac{1}{2}$. If a man gets $17\frac{1}{2}$ he knows it is intended for him to read. Now, my next bulletin is 18. Now, when the farmer gets 18 he will not know that such a bulletin as $17\frac{1}{2}$ was issued. On the other hand, I issued a bulletin intended for the farmer only. It is not on any subject of investigation, but simply a notice to farmers, informing them of the organization of the station and other matters not of importance to other stations. I called that $12\frac{1}{2}$. Perhaps some of the stations got that bulletin. I got no requests for $12\frac{1}{2}$ and few for $17\frac{1}{2}$. I think that solved the question without any difficulty at all.

There was one other question that troubled me. I wrote to Maj. Alvord as to what matter should be included in the annual report of the station. If you will read the law closely you will probably understand it as I did. It was not the intention of the law that we should make a detailed statement of the results of experiments in the annual reports. It requires that we should send so many copies to the Secretary of the Treasury and one copy to each of the stations. It makes no provision for sending them to farmers at all.

Mr. HARRIS. May I ask a question of the last speaker? Director Redding is one of the most exact and systematic of men, and if we all kept records as he does any system would work. But this bulletin— $17\frac{1}{2}$ —does it have any relation to 17?

Mr. REDDING. None whatever.

Mr. HARRIS. There is the danger. Suppose you have a second edition of 17½, with some additional matter, what would you call it?

Mr. REDDING. I would call it "17½, second edition, revised and corrected."

Mr. HARRIS. We know that if Director Redding is going to send out bulletin 17½ we will get it. But you will remember that there came a time in Egypt when they knew not Joseph, and there will come a time when we know not Redding, and I venture to say that that man will not send out 17½. Now, how do we know that we will get 48½?

Mr. REDDING. The bound volumes will contain every bulletin issued by the station.

Mr. HARRIS. How often do you issue that bound volume?

Mr. REDDING. It is issued every two years. Our bulletins are fourteen or fifteen in number, of twenty-eight or thirty pages each, and it was for my own convenience that I put two years together. But, if this association thinks it desirable to have bulletins for a year bound together, I will gladly make the change.

The PRESIDENT. There was a resolution passed at an earlier session of this convention by which the chair should appoint a committee of nine persons to act as an advisory committee to the standing committees on the coöperative college and station exhibits at the World's Columbian Exposition, consisting of members of the governing board of colleges and stations. I will appoint on that committee Messrs. Henry Chamberlain, of Michigan; W. R. Cavitt, of Texas; James A. Beaver, of Pennsylvania; H. B. Dale, of Wisconsin; Hart Gibson, of Kentucky; R. H. Warder, of Ohio; Daniel Needham, of Massachusetts; William L. Rynerson, of New Mexico; and John Cameron, of Mississippi.

Another resolution requiring the appointment of a committee by the chair was for supervising dairy tests at the Chicago Exposition. I will appoint as a committee for nominating four persons suitable for members of this committee Messrs. Neale of Delaware, Atherton, Myers, Henry, and Gulley.

Mr. HENRY. I do not think that the stations ought to feel that any bulletin ought not to go into the libraries of other stations. If you issue a bulletin to farmers, giving information in regard to your stations, that is a part of the station work and other stations should have that to bind up in the history of the work of your station. I do not think that kind of a fellow feeling ought to exist. Then, again, by inserting a paragraph on the title-page of the bulletin informing the farmer readers that the previous bulletin was not for general distribution, but could be obtained on application, you would be able to number bulletins uniformly and save all trouble.

Mr. SCOTT. Gentlemen of the association, President Broun has been called away and has asked me to take the chair.

MR. FAIRCHILD. I wish to emphasize what Dr. Johnson has said in regard to the contents of bulletins. I hope the committee will take into consideration especially the whole matter of title-paging, showing the contents of bulletins in addition to consecutive numbering. It seems to me we ought to be able at a glance to tell what a bulletin contains.

We have, I am sorry to say, followed two methods in issuing our bulletins, but not with reference to numbering. We have numbered them consecutively from the beginning. We did attempt for the first two years to republish all important matter for preservation in an annual volume, but we found that a very expensive way of presenting to the public what we thought important for them to have. We have therefore adopted the plan of inserting a notice in each bulletin that the bulletins for that year, beginning with number so and so, will be indexed in the annual report for that year. We also reserve a thousand copies for binding ourselves, and if any station worker desires a bound volume we shall be glad to furnish it.

I should like to present to that committee, when appointed, a title-page of one of our bulletins, to see if there are any suggestions in that which they can adopt.

MR. HADLEY. I have been extremely interested in this discussion and I like very much the remark of President Fairchild that the matter of title-paging should be taken under consideration by the committee.

There is one other point I would like the committee to consider: The best method of handling these bulletins after we get them. We are getting bulletins from nearly 50 stations. What is the best method of filing these while unbound. The matter of indexing, as Mr. Fairchild has spoken of, on the outside page is a matter of very great importance, but I think, however, it is generally adopted at the stations. I think most bulletins have an index on the front page. I had the honor of making a motion to that effect two years ago at Champaign. I think, however, it should be considered by this committee.

MR. CLUTE. In making up our publications for binding I have observed a difference in size. If we could adopt a uniform size for a page, print on a page so many inches wide and so much margin, then one could bind these publications into a volume and they would appear more orderly and systematic on our library shelves than where of different sizes. It would be very easy for the stations to adopt a uniform size if the committee would recommend it.

I had my clerk make out a list of all the duplicates we had and forward that list to each of the stations with the statement that we would furnish these numbers to those applying for them as long as they lasted, and I am glad to say we furnished a good many to stations. I want to acknowledge the kindness of these stations in sending to me missing numbers asked for.

Mr. ROBERTS. The difficulty in getting the bulletins uniform in size rests in the fact that many annual reports and bulletins are published by the State printer, and you might as well try to move the earth as to change a State printer or his methods. Those stations like Cornell, who print their own bulletins, can easily change, do what they please, but I know in the case of our State station their bulletins are a different size from ours, and we can't get them to change. This is a very great inconvenience to us in binding our annual reports and bulletins.

I trust that the committee will see that there are no more half numbers and no more A, B, and C bulletins, if that can be done without seriously discommoding the stations.

The PRESIDING OFFICER. Is there further discussion? If not the chairman of the executive committee will make a report.

Mr. ALVORD. The resolution seems to embody what is desired and I therefore report it back to the Association with the suggestion that it now pass. Before reading let me add a word. It seems to me that if all the stations would evince the same spirit as the Georgia station, simply say that whatever the Association agrees to the station will do, the question would be easily solved. The resolution, as given above, as offered by Mr. Harris, was again read, and adopted.

The PRESIDING OFFICER. I will appoint on that committee Director Harris, of the United States Department of Agriculture, Directors Johnson, of Connecticut, Johnson, of Wyoming, Henry, of Wisconsin, and Redding, of Georgia.

The PRESIDING OFFICER. Is there any further business?

Mr. ALVORD. The regular order is the consideration of subjects coming from the botanical section.

The PRESIDING OFFICER. We will take the regular order then. The first thing in order is a paper on the treatment of apple scab by Prof. Goff, of Wisconsin. Ten minutes to present paper.

Mr. Goff then read the following paper on the "Treatment of Apple Scab."

NOTES ON THE TREATMENT OF APPLE SCAB.

During the past seven years the writer has made applications intended to prevent damages from the disease known as apple scab, due to a fungous parasite known to science as *Fusicladium dendriticum* Fck. So long a period of experiment appears to warrant certain conclusions that might have been very unsafe from one or two seasons' experiments. It is not my purpose to present here a statistical report of these experiments, but simply to mention briefly some of the facts that seem clearly brought out. Of many materials tried the copper compounds have proved most efficacious. The carbonate of copper, used in suspension in water and also dissolved in ammonia, the arsenite of copper, or Paris green, applied in suspension, and the sulphate of copper applied in compound with lime, as in Bordeaux mixture, have all proved efficacious in certain seasons, but the degree of their relative efficiency has been far from uniform, a result that seemed rather difficult of explanation until the experience of the past season. A comparison of the meteorological

logical conditions of the different seasons in which these copper compounds have been tested, with the results secured, taken in combination with observations upon the length of time the different compounds have remained upon the foliage, appears to warrant the general conclusion that the three copper compounds named, viz, carbonate of copper, Paris green, and sulphate of copper combined with lime, are efficacious in preventing damage from the apple scab nearly in proportion to the length of time that they remain upon the foliage. In the summer of 1891, in which very little rain fell in central Wisconsin after the middle of June, Paris green applied in suspension with lime proved even more efficacious than either the Bordeaux mixture or the carbonate of copper. The past season, when the month of June was exceptionally rainy, and spraying had to be performed between showers, the Bordeaux mixture proved decidedly more efficacious than either Paris green or the ammoniacal carbonate of copper. The reason for these variable results appeared to be in the great adhesiveness of the Bordeaux mixture to the foliage. In every case where this compound has been used, though it has not been applied later than the middle of July, it has remained visible upon the foliage throughout the season, and the effect of the applications made in July, 1891, were still distinctly visible upon the branches and trunks of the trees to which it was applied in October, 1892, fifteen months after the application. It thus appears that the adhesiveness of this fungicide is so great that it can be depended upon to hold its place even through abundant rains.

I may add that this compound appears to be as efficacious when used at half the strength of the original formula, *i. e.*, when 3 pounds of copper sulphate and 2 of lime are used in 22 gallons of water, as when made of double this strength.

From what has been said, it is clear that the Bordeaux mixture must be regarded as the only fungicide thus far tested that can be recommended with confidence to prove effectual against the apple scab, although under favorable circumstances either the carbonate of copper or Paris green appears to possess equal fungicide properties. Unfortunately, this compound has the objections of being somewhat difficult to spray, of requiring more or less stirring to keep it in suspension, and of losing its efficacy as a fungicide if not used promptly after it is prepared, but until we can find a preparation that is equally adhesive to the foliage and has fewer objections, we can do no better than to employ it.

Our experiments indicate that it is important to make the first spraying before the opening of the flowers. The number of applications it is necessary to make to accomplish the best results is yet to be determined. In Wisconsin the weather during and after midsummer is apt to be rather dry, and hence sprayings after July 1 are of rather doubtful value.

I may add in conclusion that a fertile soil and frequent breaking up of the orchard are found to greatly reduce the damage from apple scab, and also that certain varieties appear to possess a decided resistant power to this disease. While the use of the spray pump in the orchard will doubtless, in the long run, prove eminently profitable both in the quality and quantity of the fruit it will enable us to secure, the wise orchardist will supplement it with plant food and cultivation, as well as by the selection of varieties that experience has shown are well able to cope with this destructive enemy of our apple trees.

The PRESIDING OFFICER. Are there any remarks on the paper? If not in the regular order we will have a paper by L. R. Jones, of Vermont, on the "Comparative tests of fungicides in checking potato blight and rot."

Mr. TRACY. In the absence of Mr. Jones I have been requested to read his paper.

A COMPARATIVE TEST OF FUNGICIDES IN CHECKING POTATO BLIGHT AND ROT.

This is the fourth year in which Bordeaux mixture has been used at the Vermont Station in checking the ravages of *Phytophthora infestans*. This work has been uniformly successful. Probably every one who uses this mixture, however, wishes that a cheaper and more convenient substitute could be found. Such substitutes have been used in work upon grape and orchard diseases. In fighting this potato disease, however, we have to meet not only a different fungus, but also somewhat different conditions of development. *Phytophthora* differs most strongly from most of the orchard and vine fungi in that it does not begin its attack at the beginning of the season and spread slowly, but instead gives no external sign of its presence until the latter part of the summer. At this time, when the plants reach proper maturity, and suitable conditions of heat and moisture prevail, the rapidity of the development and spread of the disease is something almost incomprehensible to one who has not witnessed it. Your attention is called especially to these facts as explaining in part the surprisingly poor results obtained from the use of certain fungicides which in the vineyard and orchard work have gained a good reputation.

In the summer of 1891 we undertook experiments to test the comparative value of, (1) ammoniacal copper carbonate; (2) glue mixture; (3) Bordeaux mixture, half strength; (4) Bordeaux mixture, full strength. The results as reported in the publications of the Vermont Station were decidedly in favor of the Bordeaux mixture, and showed the ammoniacal solution and the glue mixture to be of little value, under the conditions of that experiment. We felt, however, that the conditions might not be such as to give these remedies a fair trial, although it was evident that they were inferior to Bordeaux mixture.

This summer (1892) a comparative test was made of twelve of those fungicides which appeared most hopeful. The work was carried on in two different fields, one a clay loam, the other a lighter, rather sandy soil; the plots were so arranged that all the fungicides were given a trial on both medium and on late potatoes; five standard varieties of potatoes were included in the experiment, and in all plots the relative value of two and of three applications was tested.

Following is a list of the fungicides tested:

First: Copper soda solution: Copper sulphate, 13.3 ounces; sal soda 20 ounces; water, 5 gallons.

Second: Copper acetate solution: Copper acetate (verdigris), 8 ounces; water, 5 gallons.

Third: Bordeaux mixture and molasses (copper-lime saccharate): Copper sulphate, 13.3 ounces; lime, 13.3 ounces; molasses, 13.3 ounces; water, 5 gallons.

Fourth: Ammoniacal copper carbonate: Copper carbonate, .55 ounces; aqua ammonia, one-third of a pint; water, 5 gallons.

Fifth: Bordeaux mixture, full strength: Copper sulphate, 1½ pounds; lime, eight-ninths of a pound; water, 5 gallons.

Sixth: Bordeaux mixture, "5-5-50," formula: Copper sulphate, 8 ounces; lime, 8 ounces; water, 5 gallons.

Seventh: Bordeaux mixture, very weak (about one-eighth strength): Copper sulphate, 2.6 ounces; lime, 2.6 ounces; water, 5 gallons.

Eighth: Copper and ammonium carbonate mixture (Dr. Chester's formula): Copper carbonate, 1.06 ounces; ammonium carbonate, 3.2 ounces; water, 5 gallons.

Ninth: Glue mixture (Dr. Galloway's formula): Copper sulphate, 2 ounces; sal soda, 2.4 ounces; Le Page's liquid glue, 1.6 ounces; water, 5 gallons.

Tenth: Modified Eau Celeste: Copper sulphate, 7 ounces; sal soda, 9 ounces; aqua ammonia, one-third of a pint; water, 5 gallons.

Eleventh: Copper carbonate in suspension: Copper carbonate, 5 ounces; water, 5 gallons.

Twelfth: Copper chloride solution (Cornell Station formula): Copper chloride 0.66 ounces; water, 5 gallons.

Each year of work upon this potato disease leads me to appreciate more strongly the fact that the greatest value of the fungicide is not in protecting the tubers from the rot, but rather in preserving the foliage from the blight. When the foliage is thus preserved the tubers come to full size and maturity, and the gain in yield, from prolonging the life of the vines three or four weeks in the fall, is very great. Such being the case, the relative values of the fungicides can be better judged from the appearance of the foliage of the treated plants than from the yields. On the other hand, the absolute gain from the use of any fungicide must, of course, be judged by the increased yield of tubers resulting from its use. I, therefore, send some photographs with this paper, which will enable you to judge of the relative values of the fungicides better than any array of figures stating the varying yields. The full yields will be published later, and I will now select from the figures before me only enough to enable you to judge of the absolute gain from the use of some of the better fungicides. There were two rows of potatoes in each plot in the field shown in the photographs. Two of the photographs (the 8 by 10's) show some of the plots as they appeared September 10. These show clearly the effects of both Bordeaux mixture (plot 7) and weak Bordeaux and molasses (plot 4). No less interesting will be the appearance of plot 5 (ammoniacal copper carbonate), as shown in one of these photographs. It was found impossible to bring out with equal clearness the less marked differences between most of the plots by photographs, and, therefore, instead of attempting to include the entire plot in the photograph, an average hill was photographed from each plot. This explanation will, I trust, be sufficient to enable each who chooses to examine the photograph to do so understandingly.

The gain from spraying this year was unusually marked, owing to the prevalence of the disease. This can be judged from the following statements of yield of those plots shown in the 8 by 10 photographs:

	Bushels per acre.
Plot 4 (weak Bordeaux mixture and molasses) at rate of.....	330
Plot 5, ammoniacal copper carbonate.....	99
Plot 6, untreated.....	97
Plot 7, strong Bordeaux mixture.....	246.5

These experiments, supported also by data of last season's work, lead me to the following conclusion as to the relative values of the fungicides for the potato blight:

(1) Copper soda solution (plot 2) has merits, but is not at all equal to Bordeaux mixture.

(2) Copper acetate solution (plot 3), a fairly good fungicide, but so injurious to the foliage as to exclude its general use.

(3) Weak Bordeaux mixture and molasses (plot 4). Good results. Probably more valuable than same without the molasses.

(4) Ammoniacal copper carbonate (plot 5). Unquestionably the weakest fungicide tested, being but little better than nothing. (I should feel less confident in this verdict did not all the results agree so perfectly in all my experiments. I am convinced that I do not underestimate its value for this work).

(5) Strong Bordeaux mixture (plot 7) leaves but little to be desired in the results obtained.

(6) Weaker Bordeaux mixtures (plots 8 and 9) were not equal to full strength Bordeaux mixtures, as can be seen from following yields:

(Field A was of medium early potatoes, which blighted badly when not protected. Field B was of late potatoes and on lighter soil, hence not so badly diseased.)

[Bushels per acre.]

	Plot 6 (untreated).	Plot 7 (strong Bordeaux mixture).	Plot 8 (Bordeaux mixture, 5-5-50).	Plot 9 (Bordeaux mixture one-eighth strength).	Plot 11 (untreated).
Field A	97	246½	155	145	119
Field B.....	108½	189½	177	122	91½

Owing to certain conditions of soil I think the above figures in Field A would underrate the value of Bordeaux mixture "5-5-50" formula, but I am convinced that this formula does not give as good protection as does the strong Bordeaux mixture. While the very weak Bordeaux mixture had greater fungicidal value than many others tried it did not have enough to recommend it for general use.

(7) Copper and ammonium carbonate mixture (plot 10) was of some value, but not enough to be recommended for general use.

(8) Glue mixture (plot 12) ditto.

(9) Modified eau celeste (plot 13) gave best results of any of the soluble fungicides, and although not equal to either of the stronger forms of Bordeaux mixture it is the best thing to recommend where a soluble fungicide is desired.

(10) Copper carbonate in suspension (plot 14), of considerable fungicidal value, though not enough to recommend its practical use.

(11) Copper chloride (plot 15), of still less value than the last.

I would therefore rank them as follows in order of fungicidal value:

- | | |
|--|---|
| 1. Bordeaux mixture, full strength. | 8. Copper carbonate in suspension. |
| 2. Weaker Bordeaux mixture and molasses. | 9. Copper and ammonium carbonate mixture. |
| 3. Bordeaux mixture, "5-5-50" formula. | 10. Glue mixture. |
| 4. Modified eau celeste. | 11. Copper chloride solution. |
| 5. Copper soda solution. | 12. Ammoniacal copper carbonate. |
| 6. Verdigris solution. | |
| 7. Bordeaux mixture, very weak solution (one-eighth strength). | |

The first four did good enough work, so that I feel justified in recommending them for use by practical potato-growers. The others are none of them to be recommended, in my judgment.

Bordeaux mixture in some of its forms remains, then, as the most valuable fungicide of this work. The addition of a cheap molasses to the weaker mixture appears to increase its value by rendering it more adhesive.

The PRESIDENT. You have heard the paper read by Mr. Tracy; is there any discussion on it? If not, we will take up the next paper, "A Study of Fruit Decays," by Byron D. Halsted, of New Jersey.

Mr. Halsted presented the following:

A STUDY OF FRUIT DECAYS.

The speaker's attention was called to the subject of fruit decays by a quince-grower, who complained of a destructive rot in his orchard. Upon investigating the trouble a decay was found that was due to a fungus of the genus *Sphaeropsis*. The same orchard contained apple trees, with decayed fruit, and also pears. The apple decay was due to *Sphaeropsis malorum* Pk. Circumstances aroused the suspicion that the quince decay was caused by the same species of fungus. Cultures and inoculations were next instituted in the laboratory, and it was proved that the *Sphaeropsis* of the apple would grow upon the quince, and that the quince upon the apple. In like manner the same relation was established between the quince and apple *Sphaeropsis*, and the one upon the pear. In short, the three fungi are probably the same, and in the complete eradication of the one, the others need to be destroyed, or else the trouble will spread from one kind of fruit to another. A worthless overburdened apple tree may, through neglect, shorten the crop of quinces by being a propagation bed of decay.

A systematic study of the probable relationship of the anthracnoses of fruits was led up to by the above investigation. Under the term anthracnoses are included the members of the two nearly related genera, *Glucosporium* and *Colletotrichum*.

They differ from each other somewhat in general appearance, but chiefly by the presence of stiff dark hairs in the spore spots in the colletotrichums—they being absent in the glæosporiums. A very large number of species have been established in each genera and the list is increasing yearly. Many kinds of fruit are attacked by them, as well as other parts of plants.

The laboratory experiments consisted chiefly in transferring the virus from an affected fruit to one in health. The common apple ripe rot, or "bitter rot," is a familiar example of the anthracnoses, and bears the botanical name *Glæosporium fructigenum* Berk. Spores of this were transferred to several other kinds of fruit with success, thus producing artificially the disease similar to that of the apple. Previous to this series of experiments the Division of Vegetable Pathology at Washington had shown that this "bitter rot" of the apple was the same as a certain decay of the grape fruit.

At this point in the treatment of the results a chart was shown by means of which the facts established were presented in a graphic manner. The following fifteen fruits, representing widely different orders of plants, were represented as arranged around an oval, as follows: Apple, peach, banana, pepper, bean, persimmon, lemon, watermelon, quince, citron, grape, tomato, eggplant, pear, and squash. The successful inoculations from any fruit to another were shown by lines and arrows, the lines being in fact the arrows. Thus, if the fungus was a *Glæosporium* a dotted line was employed, and if a *Colletotrichum* a solid line was used. The apple has native to it a glæosporium as above mentioned. The chart showed dotted lines running from the apple to the peach, banana, pepper, bean, persimmon, lemon, quince, grape, tomato, eggplant, and pear; in fact, to all that were inoculated. The pepper has a *Glæosporium* (*G. piperatum* E. & E.) This was successfully taken to the apple, as also to the grape, and to the banana, bean, persimmon, and pear. This is strong evidence that either *G. fructigenum* Berk and *G. piperatum* E. & E., have both a much wider range of hosts than supposed, or else are the same fungus. The differences in size of spores and filaments do not warrant specific distinction. In like manner the tomato has a species, *Glæosporium fomoides*, Sacc. recorded upon it. This was easily taken to the apple, banana, bean, grape, eggplant, and pear, thus suggesting that this is the same as the one with which the experiments started on the apple.

It is not necessary to go further, the chief point of the paper being, first, that the anthracnoses of fruits are probably fewer in species than supposed, and a few may cause all the damage attributed to many. This closer relationship of these decays suggests the still greater importance of not letting one decaying fruit serve to propagate the disease for another. Lastly, the graphic method of showing the whole work of inoculation at a glance was offered as possibly useful for illustrating other similar results of laboratory investigations.

The PRESIDENT. Is there any discussion on the paper? If not, the next is a paper on breeding of fruits, by N. E. Hansen, of Iowa.

In absence of Mr. Hansen, the following paper was read by Mr. Pammel, of Iowa:

NOTES ON THE BREEDING OF FRUITS.

This subject is one of great practical importance to the Northwest. The wonderful results attained by crossing and hybridizing in improving our flowers, grapes, and some of the small fruits, lead us to expect that similar results can be achieved with the orchard fruits. Comparatively little work has been done in this line, because results are not so speedy, and we have been satisfied with chance seedlings, allowing insects and the wind to do most of the work for us. But the peculiar and severe climate of the Northwest requires that we should endeavor to originate new varieties better adapted to this vast region. The indiscriminate sowing of seeds is an expensive lottery. Breeders of animals select the parents;

why should not breeders of fruits do the same? I regard crossing and hybridizing as a method of abridging the process of evolution by introducing new elements of variation. The primitive types peculiar to each region should be used, if necessary, for one side of the cross, to impart hardiness, because they have as a rule become fully adapted to their environments by ages of natural selection, resulting in the "survival of the fittest." The theory we generally follow is that the pistillate parent is more apt to transmit hardiness, and the staminate parent size and quality of fruit.

Extensive series of experiments in this line were inaugurated at the Iowa Agricultural College in 1886 by Prof. J. L. Budd, and have been continued up to the present time. The results so far are very promising.

It may be of interest at this time to note some of the results of our work and the most promising lines of work in improving our fruits.

In bulletin No. 14 of the Iowa Experiment Station, Prof. J. L. Budd gives a summary of results attained in breeding orchard fruits. It is shown that seedlings obtained from crossing Russian apples, or from crossing Russian with American apples, are much superior in leaf, tree and habit of growth to seedlings of purely American apples, descendants of west European varieties. The same relative superiority was noticeable the past season. The seedlings in leaf, bud, habit of growth and hardiness follow the mother, and the few specimens of fruit obtained to date show modifications due to the male parent. It is evident so far that these seedling apples, of partly or wholly Russian parentage, inherit the scab-proof characteristic of the Russian race of apples (see Bulletin 18 Iowa Experiment Station) and we hope that among them will be found desirable additions to the fruit lists for our northwestern prairies. The aim of the work has been to secure iron-clad varieties of high quality for all seasons, and the work will be continued.

In crossing pears the object has been to cross the hardiest of the east European varieties with those of the highest quality of west European parentage.

In crossing cherries, the aim has been to cross the hardiest sour cherries from east Europe with the best sweet varieties, also to improve the native *Prunus pumila* and *P. pennsylvanica*. In the present year we failed in our work with the two latter species, but the work is not abandoned.

In improving our native plums the object has been to obtain high quality by using as the staminate parents the best European and Japan plums. If the cross proves so violent as to affect injuriously the productiveness and hardiness, the same method will be followed as in improving the grape, viz: to use the pollen of these hybrid varieties on our wild plums, thus securing a smaller infusion of foreign blood.

Some seedlings of De Soto crossed with a large blue plum grown in Oregon, show important modifications in foliage and fruit, and are of interest in this connection.

In the work of improving our cultivated grapes the aim has been chiefly to use Worden as the best member of the Concord family, for earliness, hardiness, and productiveness, and to use varieties of partly *Vitis vinifera* parentage to obtain high quality. This is because the history of Rogers' and other hybrid grapes show that to use a variety of purely European blood makes the cross too violent for the best results as to hardiness and productiveness, and it is hoped that better results will be obtained by using a smaller proportion of foreign blood. Hence Worden and other early Concord seedlings have been crossed with Agawam, Salem, and other Rogers' hybrids.

The same method should be followed in improving our wild grape. The Northwest greatly needs a grape of good quality that is early enough to ripen even in North Dakota and Minnesota, and is perfectly hardy without winter protection.

The past season our wild grape has been crossed with Empire State to determine the effect of using a variety considered to be of purely native parentage. Worden has also been crossed with our wild grape.

In crossing grapes I found that the caps and stamens could be removed with much facility by using the tips of the fingers as well as the pinchers. Also that pollenizing could be performed to good advantage by taking clusters of bloom just opened and fastening them with string and fine wire in close proximity to the emasculated clusters. This is much easier than gathering the pollen and applying it with a camel's hair brush. Paper sacks were used until the grapes were well set, then mosquito netting.

Our native hazelnuts, walnuts, hickorynuts, and chestnuts, all merit our careful attention, as they are no doubt capable of vast improvement by crossing and selection. Especially promising is our wild hazelnut, as it probably would soon rival the best filberts.

Our native gooseberries crossed with some large English varieties would likely yield valuable results. The past season we have crossed a hardy gooseberry from the Amur Valley in Asia with the Industry. The object is to obtain a hardy, mildew-proof variety with fruit rivaling in size and quality the best English gooseberries.

The Northwest needs a good variety of raspberry hardy enough to bear well at the North without winter protection. With this end in view, we have this season crossed a wild red raspberry from the Black Hills with the Shaffer's raspberry.

Similar work remains to be done with our indigenous currants, juneberries, blackberries, dewberries, strawberries, and other fruits. This may well be termed fundamental work in horticulture, and deserves the most careful attention of our experiment stations.

While not properly coming within the scope of this paper it may in conclusion be of interest to note that we are endeavoring to originate a new race of hardy double roses. Several varieties of *Rosa rugosa*, imported from Russia by the Iowa Agricultural College, have proven perfectly hardy without winter protection, have large fragrant flowers and are perpetual bloomers, but the flowers are single. The past season we have crossed them with a member of choice double roses, such as General Jaqueminot, American Beauty, Magna Charta, Madam Masson and Triumph de Exposition, and now have fully 20,000 seeds put away for spring planting. Some work has also been done with other primitive species, including our native *Rosa blanda*.

The PRESIDENT. You have heard the paper of Mr. Hansen; is there any discussion on it? If not we will proceed. The last paper of the evening is "The Crossing of Cucurbits" by Prof. Pammel, of Iowa.

Mr. Pammel then read the following paper:

THE CROSSING OF CUCURBITS.

In 1891 the writer read a paper* before one of the horticultural societies in Iowa in which the statement was made that melons and cucumbers do not mix, nor do pumpkins and melons. He was vigorously assailed by horticulturists for teaching doctrines which were heretical. Many claimed to have observed from actual experience that they do "mix." Nearly every one with whom the writer conversed had one opinion in this matter; that they would cross. I have not endeavored to get the opinion of seedsmen on the point. In conversing with Prof. Barrows, who has had considerable experience, I am informed that he has never known them to "mix." My brother, who grows many cucurbits, believes that pumpkins and squashes and cucumbers and melons will mix.

To settle this matter, so far as the writer was concerned, a series of experiments were undertaken. In this paper nothing more than some preliminary statements can be made, inasmuch as it will be necessary to grow the cucurbits another year

* The effects of cross-fertilization in plants. A paper read before the Northern Iowa Horticultural Society, December, 1891.

before conclusions can be reached. This paper must be considered as supplementing the excellent work of Naudin,* Bailey,† Sargent,‡ and others. To Naudin belongs the credit of having thrown much light on the subject of *Cucurbitaceæ*. During many years he experimented with a large number of varieties from different places. He found that the species did not "mix," and that when hybrids were produced they yielded either no seed or sterile seed.

Bailey remarks: "Many careful hand pollinations have been made between these two classes of fruits (*C. maxima* and *C. pepo*) and in no case have seeds been procured. Sometimes the fruit will develop for a time, and in two or three instances a summer crookneck pollinated by a turban squash has developed till half grown and has persisted until the end of the season, but it was seedless. All our experiments show that *Cucurbita pepo* and *C. maxima* do not hybridize." M. M. Vilmorin-Andrieux § says: "And we may remark that we do not know any form of gourd that should necessarily be considered a hybrid between any two of these species." But Thomas C. Gentry || speaking about hybrids between *C. pepo* and *C. ovifera* says: "Here it is evident, is a case of hybridism brought about through the agency of bees, whereby a cross between two closely allied species has been effected in an eminently successful manner, if the size, quality and profusion of the fruit are any criterion."

To insure if possible a perfect intermingling varieties of the following melons, cucumbers, pumpkins and squash were planted: *Citrullus vulgaris*, *Cucumis melo*, *Cucurbita maxima*, *Cucumis sativus*, *Cucurbita pepo*, gherkin, and dipper gourd.

This plan gave excellent facilities for the varieties of *Cucurbita pepo*, *C. maxima*, *Citrullus vulgaris*, *Cucumis sativus*, and *C. melo* to grow together. This was done to test the point frequently made by many that watermelons taste like pumpkins when growing close to them. I was also told that hand pollination would not give as good results as the natural method. But there is by no means unanimity on this point by growers of melons. Some believe the effect is seen the first year, while others believe that it can only be detected the second year.

Our experiment was unfavorable in some respects, due to a late season and the destruction of most of the melons by boys, but such as remained showed no traces of pumpkin. The Perfection Gem (*Citrullus vulgaris*) grew right among the pumpkin vines, Sweet Sugar pumpkin and Perfect Gem squash (*Cucurbita pepo*), and the two species tested were considered excellent, with no foreign taste. Montreal Improved (*Cucumis melo*) growing in with the vines of Sweet Sugar pumpkins (*Cucurbita pepo*) had an excellent flavor.

So far as the work has been carried out two questions only can be discussed: (1) Immediate effects of crossing; (2) prepotency of pollen. In all of the varieties grown in the field, while fertilization was affected by insects, no immediate effects were observed. But some of the varieties showed great variability, especially of *Cucurbita pepo* and *C. maxima*.

In the nest-egg gourd (*C. pepo*) many had of course the shape of an egg of a dirty white color. Others were flattened on the "blossom" and "peduncular" end, with the greatest circumference in the middle of a transverse section. Others were mottled with green and white, elongated in shape, narrow at the "peduncular" and "blossom" end. In the Perfect Gem, also, great variability was found. Some specimens were two or three times the normal size, flattened at the "blossom" and "peduncular" ends, having the greatest circumference in the middle of a transverse section. Still others were barrel shaped. Still others were more or less conical at the "blossom" end. In the Long Warted, some resembled the pumpkin, showing no warts; some were shaped like a crookneck, but without warts. In the Vegeta-

* Annales des Sc. Nat. Bot., 4th series, Vol. VI, 1856, p. 5.

† Third annual report of the Cornell University Exp. Sta., 1890, p. 180.

‡ Memoirs sur les cucurbitacees, 1826.

§ The Vegetable Garden, p. 251.

|| American Naturalist.

ble Marrow (*Cucurbita maxima*) some were marked with green and yellow and some almost entirely green, others a creamy yellow. In all of the cases, these peculiarities or deviations were traced to plants arising from distinct seeds and in no case were any immediate effects of crossing observed. About four hundred hand pollinations were made by the assistant, Mr. Stewart, and myself, assisted by two students, Messrs. Brown and Carver. Out of these quite a number set and produced perfect fruit. Only a few will be recorded here.

Common pumpkin on Perfect Gem (*Cucurbita pepo*) no indication of the common pumpkin. Nest-egg gourd (*Cucurbita pepo*) on Perfect Gem, no indication of gourd. Two specimens of common pumpkin on Long Watted (*Cucurbita pepo*), no indication of pumpkin. Marrow* on Long Watted; no indication of Marrow. Three common pumpkins on Perfect Gem (*C. pepo*), no indication of common pumpkin. Italian Striped on Sweet Sugar (*C. pepo*), no indication of Italian Striped. Four common pumpkins on Nest-egg gourd (*C. pepo*), no indication of common pumpkin. Two Hubbard (*C. maxima*) on Nest Egg gourd (*C. pepo*), no indication of Hubbard.

This is sufficient to indicate that there is no immediate effect on the fruit. Prof. Bailey says: "It is commonly said that it occurs in pumpkins and squashes also; but it certainly does not. There has never been any immediate influence whatever in any of our crosses, except such as were due to imperfect development caused by an insufficient or impotent pollen. In other words, the effects of the cross are seen only in the offspring of the fruits."

Many interesting experiments have been made to show that in many plants self-fertilization does not occur. *Trifolium pratense* has perhaps received more attention than most plants, and many interesting experiments have been made, which show that self-fertilization does not occur.† But many other plants have been experimented with and very positive evidence has been obtained to show that there are cases much more pronounced than this.

Experiments have been made with cucurbits. Halsted‡ covered ten muskmelons, and in no case did fruit develop. Bailey§ has also reported some interesting cases.

Our own experiments are not numerous but they are decisive in every case. Quite a number of muskmelons were covered and left to self-fertilize, with no development.

Can hybrids be produced between *Cucurbita pepo* and *C. maxima*?

Out of fifteen hand pollinations made only two reached maturity. Whether we have here two real hybrids can not be said until the next crop. It may be doubted, however, as we often found beetles in the flowers covered with bags. The chances are against the specimens being hybrids.

Do different varieties of *Cucurbita pepo* cross?

Out of fifteen hand pollinations made the majority set and matured.

In addition to these, others set but did not fully ripen, or grew for some time, and then rotted and dropped off. Others did not develop.

Can perfect fruit be produced between *Cucurbita pepo* and *Citrullus vulgaris*?

In only a single case did fruit develop till half ripe between Mountain Sweet and Sweet Sugar pumpkin, but here again there are grave doubts as to its having been fertilized by the pollen from pumpkin, as beetles were so commonly found in the bags.

Can fruit be produced between *Cucurbita maxima* and *C. pepo*, and between *C. melo* and cucumbers?

In this experiment in many cases reciprocal pollen was used, and there are excellent indications that these distinct species do not "mix." This experiment did not

* Sold to us as Mammoth Chili, but according to Vilmorin appears to be a Marrow, a true *C. pepo*.

† See Darwin: Cross and Self-fertilization of Plants. Beal: Grasses of North America.

‡ Bul. Dept. Bot. Iowa Agrl. College, 1886, p. 39.

§ Bul. Cornell Agrl. Expt. Station.

show the results in closely related garden varieties of the same species. The matter of crossing cucurbits is not easy. It should be remembered that of the enormous number of pistillate flowers produced on a single plant but few squashes develop. Early in the season with some varieties like Italian Striped, few of the pistillate flowers, although fertilized, developed. The fruit invariably rotted; some withered on the vine when half grown. This was true also of such forms as Golden Bush, Long Warded, Turban, and common pumpkins. So that our failures are not to be wondered at. These failures were more common early in the season than later. For this there are two causes. When the work began there was considerable rain and great liability to rot, especially pronounced in varieties with a great deal of foliage like Italian Striped.

In crossing we chose the afternoon as being more convenient, but experience soon taught us that early morning was the proper time. Aubert, who has done some crossing with melons, states that he found that the morning gave him best results.

From this work I think we may fairly conclude that under natural conditions the different species of cucurbits will not cross. The several cases in which fruit has been produced may be due to the accidental carrying of pollen by insects, especially by the striped cucumber beetle, which gets in the bag.

The SECRETARY. The section on agriculture will have a meeting just before the convening of the general session to-morrow morning.

The meeting then adjourned.

MORNING SESSION, THURSDAY, NOVEMBER 17, 1892.

The meeting was called to order in the lecture hall of Tulane University at 10 a. m.

MR. ALVORD. Mr. Chairman, I have an announcement to make. It should be noted that all sections will have an opportunity of holding meetings directly after the adjournment of the general session this morning, and it is requested that all sections should be prepared to report their organization for the next year at the general session this evening, and also to present to the general session all matters of business on the part of the sections which require confirmatory action of the Association in general session. The regular program of the convention provides for sessions of all the sections this afternoon, and, so far as I know, there is no disposition to change that feature of the program, but there is from the local committee an invitation to all members to participate in an excursion on the river to Chalmette and Southport, which starts at 1 o'clock.

It is desirable that sections having programs to announce should announce them now. I will repeat the statement made last night that the college section, which meets on the adjournment of the general session, will listen to a discussion on "Waste in College Work," to be opened by President Smart, of Purdue University.

President Nicholson, of the Louisiana State University and Agricultural and Mechanical College, desires to make a statement.

MR. NICHOLSON. I wish to say to the convention that I will have to leave for Baton Rouge this afternoon and will take this opportunity of saying that the most cordial invitation is extended to all the delegates

here to come to Baton Rouge to-morrow. It is understood that a special train will leave here to-morrow morning at 7 o'clock. It is contemplated that you will stop at one or two of the principal sugarhouses on the way, and you will probably reach Baton Rouge about 12 o'clock, or, perhaps, a little later. We will give you dinner there, but inasmuch as you will only be there about four hours we do not propose to make it a social dinner, because we want to show you something else. On the return trip the train will leave at 4 o'clock, in time for you to catch the evening trains here. Should you desire not to come back to New Orleans you can leave just as well from Baton Rouge as here. I observe that there are about one hundred and forty delegates here. We shall expect all of these one hundred and forty delegates to-morrow at Baton Rouge.

Mr. LEE, of Mississippi. I make a motion that a committee be appointed to designate officers for the Association for next year.

The motion was carried.

Mr. LEE, of Mississippi. I desire to present the following resolution:

Resolved, That this Association approves the recommendation of its president as contained in his annual address, and suggests to each institution receiving the benefits of the land-grant act of 1862 that there be placed in its library a bust of the author of that law and of the supplementary act of 1890—the Hon. Justin S. Morrill, of Vermont; that this subject be referred to the executive committee of the Association for appropriate action.

The PRESIDENT. Without a motion this will be referred to the executive committee.

The SECRETARY. Mr. Chairman, I have a telegram from Washington:

WASHINGTON, D. C., November 16, 1892.

A. W. HARRIS, for the Convention of Colleges and Stations,

New Orleans, La.:

Regret I can not leave. Reports are being prepared to the President of both the Department and the Exposition, to be presented this week. I wanted very much to look into your faces once more, officially, and to feel the inspiration of your work, but other duties intervene.

EDWIN WILLITS,
Assistant Secretary.

Mr. ARMSBY. I desire to offer a resolution:

Resolved, That the representatives of this Association upon the supervising committee for the Dairy Test at the World's Columbian Exposition be instructed to confer with Chief Buchanan in regard to editing and publishing the detailed records of said tests and to coöperate in making available to the experiment stations and the public the scientific and practical results.

The PRESIDENT. If there is no objection this will be referred to the executive committee.

Mr. ALVORD. I move, individually, that a committee of three be appointed to consider the courtesies extended to delegates to this convention during its session and to report appropriate resolutions thereon to the evening session of this Association.

The motion was carried.

The PRESIDENT. Is there any other miscellaneous business?

Mr. SANBORN. I offer the following:

Resolved, That it is the sense of this convention that the programs for future conventions be confined mainly to administrative and experimental questions that occur in the work of the colleges and stations, to the end that errors in methods of research, teaching, and administration may be eliminated and that the best methods growing out of common experience may be introduced by the several colleges and stations of the country.

This resolution was reported adversely by executive committee and was not adopted.

The PRESIDENT. If there is no other miscellaneous business we will proceed in regular order. We will now have a report by Director Armsby, of Pennsylvania, on the collective station exhibit at the World's Columbian Exposition.

Mr. Armsby submitted the following report:

REPORT OF COMMITTEE ON COÖPERATIVE STATION EXHIBIT AT THE WORLD'S COLUMBIAN EXPOSITION.

Your committee is glad to be able to report substantial progress and to express the belief that, if the contributions which have been promised are forthcoming at the proper time, we shall have an abundance of material for a most full and creditable exhibit of the work of the American experiment stations.

At the outset of our report it seems proper to call attention to the fact that we are reporting upon one aspect of a coöperative work. The initiative in this matter, it will be remembered, was taken by the U. S. Department of Agriculture, and it was the presentation of the subject by Mr. A. W. Harris, director (then assistant director) of the Office of Experiment Stations, at the convention of 1890, that led to the appointment of this committee. The resolution under which we were appointed recognized these facts and directed us to coöperate with the Department. These instructions have been strictly complied with and there has been the fullest and freest coöperation at every step. Whatever success the exhibit may meet with will be very largely due to the generous financial aid of the Department of Agriculture and to an even greater degree to the personal interest and counsel of its officials, especially of Assistant Secretary Willits.

Relations to the college exhibit.—It will be remembered that at the last convention of the Association a committee on a coöperative college exhibit was appointed and that the committees were instructed to coöperate. It was the understanding of both committees that the purpose of the Association in this action was not to set up two separate exhibits side by side, but to make the special work of each committee an integral part of a single combined exhibit of the twofold work of instruction and experimentation carried on by the institutions represented in the Association. There has, therefore, been the fullest coöperation and harmony between the two committees at every stage of the work, and, indeed, in all matters pertaining to the exhibit as a whole they have practically acted as one committee. While, consequently, this report relates specifically to the exhibit of the stations, it will necessarily include some references to points relating to the college exhibit.

Since its last report your committee has held meetings jointly with the college committee as follows: at Chicago, October 27 and 28, 1891; at Washington, September 15 and 16, 1892; at Chicago, November 12, 1892, and during the present convention. The chairmen of the two committees also had a conference with Chief Buchanan, of the agricultural department of the Exposition, and with the U. S. Department of Agriculture on January 27, 1892, at which time a definite assignment of space was made for the exhibit. It does not seem necessary to go into a detailed

report of these various meetings. In place of that we desire to present a brief, general statement of what has been accomplished up to date.

Scope of the exhibit—As was explained in the former report of our committee and in the various circulars which it has issued, the exhibit is to be a “coöperative exhibit,” showing the work of the institutions as a whole, rather than the complete work of any one institution. As intimated above, it is to be a unified exhibit, showing upon one side the experimental work of the stations and on the other the teaching work of the colleges. Between these two, and forming a connecting link, there are to be located such exhibits of the equipment and lines of work of the individual institutions as can be made by means of pictures, charts, etc., and also the working laboratories, showing the equipment for investigation and instruction, respectively, and exhibiting some of the simpler and more striking operations in each. It is also regarded as essential that competent demonstrators shall be in attendance to explain the exhibit. This it is hoped to provide for by a loan from the various stations of the services of one or more of their assistants for a limited time. This subject was before the general meeting of the two committees at Washington in September last, and the following resolution was adopted as expressing the judgment of the committees on this point:

Resolved, That, in the opinion of the committee, each college and each station should be requested to provide one attendant, who shall remain at the Exposition one month as demonstrator, his expenses during that time to be defrayed by the college or station sending him.

Location.—A vote of the Association at its last convention referred the question of the location of the experiment station exhibit to this committee in consultation with the Department of Agriculture and with the executive committee of the Association. At a joint meeting of the college and station committees in Chicago in November, 1891, this question was carefully considered and a change of location from the Government building to the Agricultural building was decided upon. The principal reasons for making the change were: First. That the college exhibit could not be made in the Government building, and the change was, therefore, necessary in order to combine the college and station exhibit into a whole. Second. That it was found possible to obtain considerably more space for the exhibit in the Agricultural building than was available in the Government building. Third. That a location in the Agricultural building would bring the exhibit more directly and effectively before the farmers of the country. The position assigned to the exhibits is a very advantageous one in the southwest corner of the Agricultural building, on the main floor, and immediately adjoining the exits leading to the colonnade connecting the Agricultural building with Machinery Hall and also the entrance to the Assembly Hall. The total amount of space assigned is 8,599.5 square feet, or nearly one-fifth of an acre. This is exclusive of the exterior aisles, varying from 10 to 18 feet in width, which surround the whole space. In this connection we desire to express our appreciation of the interest in our exhibit manifested by Mr. W. I. Buchanan, chief of the Department of Agriculture, especially as shown in this very liberal allotment of space, which, it should be added, was made considerably in advance of most other assignments in order to enable the committee to carry on its work to the best advantage.

Securing exhibits.—The main work of the committee, of course, has been the securing of exhibits typical of the work of the stations in their various departments. For this purpose, as explained in a former report, the preparation of each of the several departments of the exhibit was put in charge of a specialist under the general authority of the committee. These gentlemen and others whom they have associated with themselves have contributed freely of their time and ability to the work, often at considerable personal inconvenience, without other recompense than the satisfaction arising from the sense of contributing to the general welfare. Some changes have been necessary during the year, certain gentlemen finding it impossi-

ble to carry the work. Prof. Paquin, in charge of the veterinary portion of the exhibit, has severed his connection with experiment station work. His place was filled by the appointment of Dr. W. L. Williams, of Purdue University, who in turn finds himself unable to continue the work, and Prof. E. A. A. Grange, of Michigan, has been requested to take charge of it. Messrs. Cooke and Thorne have felt obliged to resign the charge of the dairy and fertilizer exhibits, respectively, on account of very great pressure of work, and Messrs. H. H. Wing, of Cornell, and M. A. Scovell, of Kentucky, have been appointed in their places. All those in charge of specific departments of the exhibit have been appointed special agents of the Department of Agriculture, so that the expense of postage has thus been provided for. The committee has received full reports from all but one of these gentlemen. These reports need not be gone into in detail, but in general it may be said that in nearly every case the contributions promised are sufficient to insure a most interesting and typical exhibit of the work of the experiment stations in these several departments.

Work still to be done.—As will appear from what has been said, your committee feels that it has good grounds for confidence in the success of the exhibit. At the same time it is the part of wisdom to face fairly and fully the fact that abundance of time still remains in which to make a most disastrous failure. The buildings of the Exposition will soon be open for the reception of exhibits. With all the work which has been done your committee is as yet able to put its hand upon very few exhibits that are actually prepared and ready for shipment. We have plenty of promises and we have every reason to believe that they will be honored, but it will not do to ignore the fact that very much still remains to be done.

Your committee is fully alive to its own responsibility in this particular. It has received, as already stated, detailed reports from most of the gentlemen in charge of the different departments of the exhibit, showing what exhibits had been offered in their several departments and the amount of space and size and style of cases desired, and it also expects similar reports from the others in the immediate future. At its meeting last week in Chicago, it also, in company with the director of the Office of Experiment Stations, representing the Department of Agriculture, and with numerous delegates to this convention, visited the Agricultural building and conferred with Chief Buchanan. Having all these data in hand, it is the purpose to proceed at once, in coöperation with the Department of Agriculture, with the designing and construction of cases and the arrangement and coördination of the exhibit as a whole. This work will be pushed forward as rapidly as possible, and we hope to have ready in ample season all the cases, etc., needed for the installation of the exhibit. But here our power ends. We can put the cases on the floor of the Agricultural building, we can arrange them and label them and decorate them, but we can not fill them.

We desire to impress upon every delegate present the importance of prompt action in the preparation of exhibits. Those of us who have visited the Exposition grounds and have seen the immense buildings begin to realize the enormous amount of material which will be brought in there during the next six months. Very thorough arrangements as to the shipping and receiving of exhibits are being perfected by the Government board, and we shall share in their benefits, but at best the proper installation of the exhibit under such conditions will require considerable time. It can be accomplished at all only by having all the material ready for shipping early, so that it may be on hand promptly when needed. The success of the exhibit, in our judgment, depends more upon this than upon any other point.

We hope we may count also upon the interest and the support, moral and material, of governing boards and of those in control of the financial affairs of the various institutions. While the committee has, in general, met with a hearty and encouraging response to its requests, it has been surprised and somewhat disheartened by the apparent indifference of some institutions and the direct refusal of others to give any material aid or encouragement to the exhibit. Such instances

have led us to fear that the importance of this undertaking and the advantages sure to flow from it, if successful, as well as the very serious consequences of a failure, are not even yet fully appreciated. We believe that a reasonable contribution to this coöperative exhibit is both the duty and the privilege of every station. The United States is now appropriating nearly \$700,000 annually to these stations. We believe it has a moral, even if not a legal, right to call upon them, through the Department of Agriculture, to improve this opportunity of showing to Congress, to the people of the United States, and to the world what use they are making of the most magnificent public provision for agricultural experimentation which the world has yet seen. The various State governments, too, are appropriating annually about \$150,000 more. They, too, have a right to expect a good showing from their beneficiaries. If we make a meager, discreditable exhibit, the people who pay the taxes will hardly fail to draw the conclusion that the stations are failing to properly administer their trust.

Nor is it our own people alone whose judgment of us will be largely affected by this exhibit. Foreign visitors will be even more influenced in their estimate of us by our exhibit, since they have scarcely any other means of judging. It is anticipated that the agricultural congresses will draw to the Exposition agricultural experts from abroad, who will be specially interested in experiment station work. Moreover, the fact mentioned in the report of the executive committee that our exhibit is to be immediately adjacent to that made by the French Government of methods of teaching agriculture, as well as to that of the Rothamsted Experiment Station, showing the results of fifty years of work, and that in all probability the German experiment stations will make a similar exhibit in our immediate vicinity, brings us into direct competition with these nations. If we fail, we fail before the eyes of the world.

On the other hand, a good exhibit, such as we can easily make by united effort, one which shall properly set forth the range and variety of our work and its economic importance, will, we believe, do more to strengthen each station, even with the people of its own State, than any similar effort otherwise put forth. The occasion presents a great opportunity and a great public duty. There is a tide in the affairs of stations as well as of men. Shall we take it at the flood?

Respectfully submitted.

H. P. ARMSBY,
W. A. HENRY,
CHAS. E. THORNE,
S. M. TRACY,
G. E. MORROW,
Committee.

Mr. DABNEY. I am glad indeed to get the information contained in this paper. It contained a great deal that we wanted to hear. The gentleman who prepared the report mentions the fact that some governing boards of institutions have been slow to act in making provision for the exhibit. If we have been, it is wholly from the want of information. This report supplies a good deal of information needed. To illustrate by our own case, I will say that we have never fairly understood exactly what part our station would take in the collective exhibit. They were laboring under the impression that the exhibit would be taken care of by the Department of Agriculture as a portion of the exhibit of the U. S. Department of Agriculture. While we have been preparing our exhibit so far we have made no provision and I do not think the trustees contemplate making a provision for the expense of taking care of the exhibit after it reaches Chicago. Our board meets

in December and it is desirable that we should know what expenses we are expected to provide for, and as it will be the last meeting before spring I would like to have a little more information along that line. What is expected of us, financially?

Mr. ROBERTS. Will you allow me to remark that there is another report which will explain what Dr. Dabney wishes to know?

The PRESIDENT. I will now name the committees appointed. The committee to propose proper resolutions for courtesies extended the convention, Messrs. Morrow, Scott, and Wiley. The committee for nominating officers for the ensuing year, Messrs. Lee of Mississippi, Goodell, Thorne, Neilson, Hadley, Loughridge, and Wing.

We will now have the report of the committee on the collective college exhibit.

Mr. Alvord submitted the following report.

REPORT OF THE COMMITTEE ON THE COLLECTIVE COLLEGE EXHIBIT AT THE WORLD'S COLUMBIAN EXPOSITION.

After the resignation of Presidents Atherton and Smart from this special committee as originally appointed, its duties were assumed by the executive committee, and the work since done is now reported upon for that committee.

Early in September an office was opened in Washington city and active operations begun to interest the trustees and executive officers of the various colleges and other institutions receiving the benefits of the act of Congress of July, 1862, and August, 1890, in the proposed collective exhibit by these institutions, in the Agricultural Building of the Exposition. While the U. S. Department of Agriculture is unable to directly recognize this effort on the part of the colleges, it has shown much interest in the subject and has in various ways materially promoted the same.

This committee has coöperated with the one in charge of the exhibit of the experiment stations and shares with the latter in the general space assigned by the chief of the Department of Agriculture of the Exposition. The laboratories for illustrating work in chemistry, botany, and zoölogy and the veterinary alcoves will occupy space to some extent common to the college and station exhibits and represent instruction and the facilities for instruction in those departments, as well as investigation therein. Adjoining the zoölogical laboratory and veterinary alcove, a rectangular space 30 by 34 feet has been assigned for the department of college instruction in agriculture and horticulture. Just across the central aisle, four apartments or divisions are laid out, to be occupied respectively by (1) chemistry, (2) civil engineering and drawing, (3) domestic and fine arts (mainly women's work), and (4) mechanic arts and engineering, including electricity. The first three named have each a floor space about 17 feet square, and the last one a space 22 by 40 feet.

It is proposed to ask the various colleges to loan for exhibit in these different departments models, apparatus, and other material showing the facilities they possess for giving instruction in the several lines named, and also material in objects, illustrations, or data, showing the results of such instruction. It is believed that the preparation of the material can be accomplished without burdensome labor on the part of the colleges and that it can be arranged to transport the same to Chicago, install and care for the exhibits, and return the property without direct cost to the contributing institutions. It becomes, virtually, a loan exhibition, the several contributors being at some trouble, but very little expense, in suitably preparing the articles for exhibition.

Every article or part of the exhibit will have proper labels attached, indicating what institution is the owner and contributor. It is not expected that any one col-

lege will largely contribute to any one department, but hoped that the colleges will generally be found ready to be represented in several different sections or departments.

The committee in the course of its work thus far has found a general desire on the part of the presidents and professors of colleges to have their institutions participate in this exhibit, but in many cases much misconception of the plan in detail and of the labor and expense involved. A greater obstacle to progress is the feeling on the part of a number of boards of trustees that they cannot afford the necessary expense and that, if they could, such use of their funds is inexpedient, if not illegal.

Your committee recommends that this subject be thoroughly discussed at the present convention, with a view to obtaining a consensus of opinion as to what the several land-grant colleges can do and what they ought to do in regard to this exhibit, including the views of college trustees, in order that the same may be formulated for the information and guidance of all concerned.

Attention is also called to the fact that this college exhibit matter is now in the hands of the executive committee which ceases to exist with the adjournment of this convention. Suitable provision should therefore be made for continuing the work.

Respectfully submitted.

HENRY E. ALVORD,
Chairman.

The PRESIDENT. We will next have the report of the committee on the World's Agricultural Congress.

Mr. Morrow presented the following report:

REPORT OF THE COMMITTEE ON THE WORLD'S AGRICULTURAL CONGRESS.

The committee of conference with the authorities of the World's Columbian Exposition, as represented by the World's Congress Auxiliary, concerning the Agricultural Congress to be held during the Exposition, take pleasure in reporting that the plans for that congress are so far perfected as to assure its marked success.

The Congress will be held during the last half of the month of October, 1893, in the new and magnificent Art Palace in Chicago, in which is provided a large number of audience rooms with seating capacity of from 300 to 3,000. If desirable, sessions of the Congress may be held in the assembly hall of the Agricultural Building on the Exposition grounds, near the collective exhibit of the colleges and stations.

As the Exposition Authorities, through the Congress Auxiliary, assume full responsibility for the congresses in the matter of providing meeting places, printing, and distributing announcements and programs, and hope to provide for the publication of the proceedings, the arrangements for each congress rest with this auxiliary, a control committee of which, mainly made up of persons living near Chicago, is appointed for each congress. There are also special committees for each division of the different congresses.

Still further, there are advisory councils composed of persons especially eminent in the department covered by the congress and honorary members of each congress.

This Association has been recognized in these committees and will be very prominently represented in the advisory council and honorary membership.

The Congress Auxiliary also invites the appointment by this Association of a committee of coöperation with the committee of the Auxiliary.

The plans for the Agricultural Congress provide for sessions of the congress as a whole, for addresses from the official representatives of agriculture in different nations, and other addresses of general interest; also for meetings of the following divisions:

(1) General farm culture; (2) animal industry; (3) horticulture (in August); (4) organization and legislation; (5) education and experiment.

So far as may be advisable the different divisions will also subdivide for sectional meetings.

Agricultural education has been assigned a place in the educational congress to be held in July, and this Association is represented on the committees for that congress.

The committee desires to express its hearty appreciation of the cordial interest shown in the Agricultural Congress by the Congress Auxiliary, through its president, Hon. C. C. Bonney, of Chicago.

The chairman also desires to express his appreciation of the aid given him by Assistant Secretary of Agriculture Willits, and his regret that it was found impracticable to frequently confer with the other member of the committee, the honorable president of this Association.

The committee has had a constantly increasing appreciation of the importance of the great series of world's congresses, of which that devoted to agriculture forms a part, and, in some sense, a climax; of the thoroughness of the plans and organization of the Congress Auxiliary and the abundant provision made for places of meeting, publication, etc., and of the widespread interest taken in many of the congresses. It records its conviction that the Agricultural Congress will be the most largely attended and most important meeting of the kind ever held, and that the extraordinarily favorable connection of this Association with the Congress makes it a duty, as well as a privilege, for the Association to exert itself to the fullest extent in utilizing this unprecedented opportunity for widening the influence of the institutions of which it is composed, not only by participation in the division of the Congress in which there is the most direct interest, but equally in each of the others.

The committee recommends that this Association, officially and through its membership, give the heartiest coöperation to the World's Congress Auxiliary of the World's Columbian Exposition, in preparing for the Agricultural Congress to be held in Chicago the last half of October, 1893.

That a committee of coöperation, consisting of five members, be appointed to aid the committee of the auxiliary, having the Agricultural Congress in charge, and also to give such assistance as may be necessary in having a suitable recognition of agricultural education in the several educational congresses to be held in July, 1893.

As it is believed it will be most advisable that the annual meeting of this Association for 1893 be held at Chicago in connection with this Congress, in which case it is important that the officers of the Association should be in intimate relations with the Congress, it is recommended that the appointment of the committee be left to the executive committee.

It is further recommended that the members of the Association nominate to the agricultural committee of the Congress Auxiliary the names of suitable persons to be placed on the advisory council, and also those best entitled to recognition as honorary and corresponding members of the Congress.

G. E. MORROW,
Chairman for the Committee.

A full discussion followed, participated in by a number of delegates, regarding the subjects presented by the three reports preceding, and the work of the colleges and stations in connection with the proposed exhibits.

Mr. MORROW. As this question involves finance, I will ask if it will not be a matter to refer to the executive committee.

The PRESIDENT. Each of these reports will be referred to the executive committee, if there is no objection. They are so referred.

Mr. MORROW. In accordance with the request of the World's Congress Auxiliary that this Association appoint a committee to coöperate with the committee on the Agricultural Congress, and owing to the important relation in which this committee stands, it should be appointed by the executive committee. I will therefore move that the recommendations of this committee be approved.

The motion was carried.

Mr. MERRY (agent of the Illinois Central Railroad). I desire to make the announcement that a special train will leave at 7 o'clock. The railroad schedule is not quite so flexible as the time for convening of the Association. It will therefore be absolutely necessary that every member of the convention who desires to make the trip shall be at the Illinois Central depot at 7 o'clock.

The Association then adjourned at 12 o'clock.

EVENING SESSION, THURSDAY, NOVEMBER 17, 1892.

The meeting was called to order by Vice-President Dabney at 8 o'clock.

The PRESIDING OFFICER. The program for this evening calls for the consideration of resolutions and general business.

Mr. Alvord here presented the program of the evening slightly changed.

The PRESIDING OFFICER. The executive committee have arranged the program as follows: First, the report of the committee appointed to confer with the Weather Bureau, Mr. Harris, chairman.

Mr. HARRIS. I am not chairman of that committee, but am requested to present the report. It is as follows:

REPORT OF COMMITTEE ON COÖPERATION WITH THE UNITED STATES WEATHER BUREAU.

Mr. PRESIDENT AND GENTLEMEN OF THE ASSOCIATION: Immediately after the close of the Washington convention your committee called upon the Assistant Secretary of Agriculture and the Chief of the Weather Bureau. Secretary Willits expressed his hearty sympathy with the Association and paved the way for numerous interviews with Prof. Harrington. He received us most cordially and declared his desire to aid us.

In order to gather together the information already in existence in regard to the relations of agriculture and meteorology, he asked your committee to suggest to him subjects which should be studied and the names of persons qualified for this work. These suggestions were promptly adopted, and as a result the Bureau has published two bulletins, with which the members of this Association are already familiar. They are: By Prof. Hilgard, on Relations of Soils to Climate; by Prof. Whitney, on Some Physical Properties of Soils in their Relation to Moisture and Crop Distribution.

Prof. Harrington has also furnished to the Office of Experiment Stations a bulletin on Meteorological Work for Agricultural Experiment Stations.

Much has also been attempted for agriculture in the regular work of the Bureau.

Cotton region service.—The Bureau has continued to render important information to cotton-growers. After consultation with the observers in charge of the several

centers and upon the urgent requests of the commercial exchanges, the time for taking and reporting the observations was extended. These are now made from April 16 to November 30 of each year. Many requests for the establishment of new stations have been received; but it has been only practicable to open two. In order to establish nine stations of a somewhat similar character in the sugar and rice growing districts, and to keep within the appropriation, it was necessary to discontinue nine of the less important cotton region stations.

Flood predictions.—There are now in active operation 166 special river stations and 59 special rainfall stations. These are arranged in groups or sections under the supervision of central stations. The river observers record the rainfall also. River bulletins are issued at 22 places. Stage predictions of some of the principal rivers are made daily at Washington and local predictions are made at many points.

State weather service.—State weather service work has been carried on to a much greater extent than heretofore; and the results accomplished prove the usefulness and importance of this branch of the Bureau. The entire territory of the United States with the exception of Alaska is now covered by local weather services, the last organized being that for Idaho. The regular monthly reports now contain important tables, and it is possible now to obtain the special features of the climate of every section of the country. Thus farmers, and all others have a means of securing detailed information.

Besides the National Bulletin, all the States and Territories, except Nevada and Idaho, issue local bulletins during the season of planting, cultivation, and harvesting of crops which form a most important feature of State weather service work. Such has been the demand for the National Bulletin that the edition has been more than doubled and yet the demand increases. The text of the bulletin is telegraphed by the press associations and is reproduced either in whole or in part in many papers.

The distribution of forecasts, frosts, and cold-wave warnings has greatly increased during the past year, but has been hampered by inadequate appropriations for telegraphic purposes. The increase in the number of stations supplied by telegraph at Government expense with the daily forecasts, as compared with the number supplied on June 30, 1891, is over 200 per cent, and on the 1st of July, 1892, our lists show a total number of 1,888 receiving a daily telegram at the expense of the Weather Bureau.

A large number of applications could not be favorably considered, as the allotment of the telegraph appropriation would not admit of any increase over the number already supplied. One hundred and thirty-six stations have been established under the auspices of the National Grange of the Patrons of Husbandry, many of which were supplied with flags by the Weather Bureau, while others disseminated the forecasts and warnings by means of steam whistles.

The railroad telegraph and train service, as gratuitous means of distribution, are largely utilized, and nearly 3,000 places receive the forecasts daily in this manner, and over 1,000 points are supplied by mail or a free telegraph or telephone service.

The PRESIDING OFFICER. What will you do with the report, gentlemen?

The report was accepted and placed in the hands of the executive committee.

Mr. ALVORD. If there are no other matters of special business to be brought up the executive committee is ready to report back the resolutions referred to it for the action of the convention.

Dr. Armsby's resolution is somewhat modified and recommended for adoption in the following form:

Resolved, That the representatives of this Association upon the supervising committee for the dairy tests at the World's Columbian Exposition be instructed to con-

fer with Chief Buchanan in regard to editing and publishing the detailed records of said tests, and to coöperate in making available to the experiment stations and the public the scientific and practical results.

The resolution was adopted.

Mr. ALVORD. The following resolution is offered by the executive committee as covering a subject that has not received the attention of the convention up to this time:

Resolved, That the communication from Chief Buchanan of the Department of Agriculture of the World's Columbian Exposition, in relation to a course of popular lectures in connection with the agricultural exhibit be referred to the executive committee with power to coöperate in this project at the discretion of said committee.

The resolution was adopted.

The resolution offered by Mr. Lee is reported back somewhat modified with recommendation for its adoption as follows:

Resolved, That this Association approves the recommendation of its president as contained in the annual address and suggests to each institution receiving the benefits of the land grant act of 1862, that there be placed in its library a bust of the author of that law and of the supplementary act of 1890, the Hon. Justin S. Morrill, of Vermont.

Resolved, That this subject be referred to the executive committee of the Association for appropriate action.

The resolutions were adopted.

The executive committee offered a resolution as to the annual dues of institutions.

Mr. ROBERTS. When the constitution was adopted I ran against the word institution, and it was not defined there so that I could understand it. Many stations are added to a college and are not institutions in any sense of the word—they are departments of institutions; so it seems to me that a little explanation is necessary in this resolution—at least it took me a considerable time to get through my head that wherever the word “institution” occurred in the constitution, and in this resolution it means a college or an experiment station, and that the dues will be \$10 for each college and \$10 for each experiment station.

The SECRETARY. I think the point well taken. I am frequently written and asked whether that means for the whole institution.

Mr. HAYS. I move that the resolution read, instead of “each institution,” “each college and each experiment station.”

The executive committee accepted the amendment, and the resolution was adopted, as follows:

Resolved, That for the ensuing year the annual dues for each college and each experiment station entitled to membership in this Association shall be \$10; and

Resolved further, That in view of possible extraordinary expenses, the executive committee be authorized to call, if necessary, for additional contributions from each college or experiment station, in which case the needs and purposes shall be fully stated.

President Turner, of West Virginia, offered the following resolution, which was handed in directly to the executive committee. The com-

mittee submitted this with the recommendation that it be referred to the new executive committee:

Resolved, That hereafter the annual sessions of the Association shall continue at least four days; and there shall be but one general session each day and but one session of each section each day.

The reference recommended by the committee was ordered.

The following resolution was offered by Mr. Sanborn:

Resolved, That it is the sense of this convention, that the program for future meetings be confined mainly to administrative and experimental questions that occur in the work of colleges and stations to the end that errors in methods of research, teaching, and administration may be eliminated and that the best methods growing out of common experience may be introduced by the several colleges and stations of the country.

The committee sympathized with the spirit of this resolution, but believed the desired object could be attained by a strict construction of the constitution without further legislation and therefore recommended that this resolution be referred to the new executive committee.

The recommendation of the executive committee was adopted.

The executive committee recommended that when the present general session adjourn, it should be to meet the next evening at Parlor P, of the St. Charles Hotel, with the understanding that nothing but the usual closing business of the convention be then transacted—acknowledgments of courtesies and so on—and that the special committee appointed on that subject be then called upon to report.

On motion the recommendation of the executive committee was adopted.

ELECTION OF OFFICERS.

The PRESIDING OFFICER. The next thing, gentlemen, according to the program is the election of officers. We will now have the report of the nominating committee.

Mr. LEE, of Mississippi. The committee submit the following names for officers for the next year:

President, W. A. Henry, Wisconsin.

Vice-presidents, W. C. Stubbs, Louisiana; E. W. Hilgard, California; John A. Myers, West Virginia; A. Q. Holladay, North Carolina; J. F. Hickman, Ohio.

Secretary and treasurer, M. A. Scovell, Kentucky.

Bibliographer, S. W. Johnson, Connecticut.

Executive committee, H. E. Alvord, District of Columbia; James Neilson, New Jersey; H. H. Goodell, Massachusetts; C. W. Dabney, jr., Tennessee; the president, junior ex-president, and the secretary and treasurer.

The PRESIDING OFFICER. Gentlemen, you have heard the report of committee. What will you do with it?

Mr. ROBERTS. I move that the report be accepted.

Carried.

Mr. HAYS. I move that the secretary be instructed to cast the ballot for the Association.

Carried, and the secretary was instructed to cast the ballot for the Association.

This being done, the nominees reported by the committee were declared to be duly elected.

The PRESIDING OFFICER. Next, reports from sections. I will call them in no particular order. The Section on College Work.

Mr. Turner reported the following nominations for officers of that section: Chairman, President C. W. Dabney, of Tennessee; vice-chairman, President George T. Fairchild, of Kansas; secretary, President M. C. Fernald, of Maine.

Mr. ALVORD. I move that the nominations for chairman and secretary be confirmed. We have nothing to do with the vice-chairman.

Carried.

Next, the Section on Agriculture and Chemistry.

Mr. HUNT. Mr. Quick was expected to make the report. I will say that the nominations were as follows: Chairman, W. A. Henry, of Wisconsin; vice-chairman, W. C. Stubbs, of Louisiana; Secretary, W. C. Latta, of Indiana.

Nominations confirmed.

Next, Section on Horticulture and Botany.

The secretary read the nominations submitted as follows: Chairman, F. Lamson-Scribner, of Tennessee; Secretary, E. S. Goff, of Wisconsin. Nominations confirmed.

Next, Section on Entomology.

The secretary said that he had been requested by Mr. Osborn to state—

That, as only two entomologists were present at the time for organization of that section and as neither of the officers was here, it was deemed best not to organize the section, and consequently no nominations were ready. And to ask that the Association elect officers for the coming year, as it is probable that there will be a better attendance and it will be desirable to have a report of progress in that line.

Mr. SANBORN. I move that Mr. H. Osborn be made chairman of the section.

The PRESIDING OFFICER. Is this regular; can it be done? I think under the constitution a section must elect its own officers.

Mr. DEPASS. I think we are equal to the occasion.

Mr. TRACY. I think the constitution says the old officers shall hold over.

The PRESIDING OFFICER. The officers will hold over.

Mr. LEE, of Mississippi. The Section on Mechanic Arts reports the following nominations: Chairman, C. W. Hall, of Minnesota; secretary, F. Paul Anderson, of Kentucky.

Nominations confirmed.

The PRESIDING OFFICER. I believe there is a committee to report at this time on the Test of dairy cows at the World's Columbian Exposition.

Mr. NEALE, of Delaware. The following resolution was handed to your committee for consideration:

Whereas this Association has received a request from the authorities of the World's Columbian Exposition to nominate four persons to be appointed members of the committee to supervise the tests of dairy cows during the exposition at Chicago; and

Whereas this is a subject of such importance as to require the most careful consideration, with a view to appropriate action: Therefore,

Resolved, That a committee of five be appointed by the Chair to consider this subject and to report to this convention the names of four persons suitable for members of the said testing committee, and to also report what further action is advisable in the premises.

Referred by the president to Dr. A. T. Neale, of Delaware; Dr. G. W. Atherton, of Pennsylvania; Dr. J. A. Myers, of West Virginia; Prof. W. A. Henry, of Wisconsin; Prof. F. A. Gulley, of Arizona.

The committee to which was referred the above resolutions respectfully reports the names of four gentlemen, viz: M. A. Scovell, of Kentucky, chairman; I. P. Roberts, of New York; S. M. Babcock, of Wisconsin; H. P. Armsby, of Pennsylvania; and respectfully suggests that the executive committee of this Association be authorized to provide, on consultation with the above-named gentlemen of the testing committee, for the payment of the necessary expenses incurred by said gentlemen in supervising said tests, funds to be secured in such manner as may be found to be most expedient.

A. T. NEALE,
GEO. W. ATHERTON,
W. A. HENRY,
JOHN A. MYERS.

The report of the committee was adopted.

Mr. SMART. The committee appointed to consider the question of compiling intercollegiate statistics has held a meeting to consider the subject as fully as possible under the circumstances. The committee finds itself unable to report a plan for permanent adoption, and it therefore has prepared a resolution which will cover the ground for the present and suggests that a committee be appointed to consider the subject further. President Atherton will read the report.

Mr. ATHERTON. The committee have had the subject under consideration and make the following recommendation:

(1) That a committee of three be appointed, whose duty it shall be, by conference with members of the Association and by such other means as they may find advisable, to prepare a form of blank which will present in the most simple and complete manner such statistics of the resources, income, expenditures, and activities of the colleges forming this Association as are likely to be most generally desired, and to gather, collate, and distribute such statistics as early as practicable.

(2) That the said committee shall report to this Association at its next convention a plan for the permanent continuance of such work.

J. H. SMART.
GEO. W. ATHERTON.
HENRY H. GOODELL.

If it is the proper stage of the proceedings, I move the continuance of the same committee on this subject.

Mr. SMART. I suggest that Mr. Atherton be made chairman of this committee as he has agreed to do the work, and it is proper that the circulars should go out in his name.

Adopted.

Mr. ATHERTON. May I make a single request of the college and station men present. That before leaving the city or immediately after, they mail me at my home a statement of the things they desire to be included in these statistics, and when we get up a blank it will contain all suggestions from all quarters.

The PRESIDING OFFICER. Anything further.

Mr. FREAR. I move that the executive committee be instructed to coöperate with the director of the Office of Experiment Stations in the preparation and editing of the proceedings of this convention for publication.

Carried.

Mr. ATHERTON. I have one more matter that I desire to bring before the Association, which I think is of importance. In the report of the Knoxville meeting on p. 96 it will be found that the Association took action previous to the incoming (present) administration at Washington for the purpose of impressing upon the President, then elect, and upon the Secretary of Agriculture to be appointed, the importance of keeping the scientific work of the Department as closely as possible under his own control and direction, so that the Secretary in his administration of the Department should so far as possible be able to coöperate with the Association. The President-elect and the new Secretary of Agriculture very cordially responded to that suggestion and the whole policy of the new Department was based especially upon the suggestion of the Association in that respect. I now suggest to the Association considering the present turn of things, a new administration coming in, whether it is not expedient and feasible that the same step should be taken? With that view I have taken up the two preambles of the resolution then adopted, which I will ask leave to read, accompanied with another preamble and a short resolution:

Whereas the Department of Agriculture has become one of the important scientific departments of the executive branch of the Government of the United States, and in reality a great experiment station in itself, its various divisions being managed in most cases by men of recognized ability and scientific attainments; and

Whereas recent years have rapidly developed the character of this Department, which, if the system of State experiment stations be included, now exceeds in magnitude any other scientific work of the Federal Government; and

Whereas this encouraging development and satisfactory condition of the scientific work is largely due to the broad-minded and enlightened policy which has been pursued for several years past of administering these branches of the Department upon a thoroughly nonpartisan basis, securing permanency in position of their officers and assistants; therefore

Resolved, That the executive committee be, and hereby is, instructed to take such steps as it may deem expedient for calling this entire subject to the attention of the President-elect, and respectfully urging upon him the continuance of the same policy; and

Resolved, That the executive committee be instructed to coöperate with the said Department, in every way possible, in advancing the character and stability of its scientific work.

The preamble and resolutions were adopted after some discussion.

The SECRETARY. I call attention to the fact that the auditing committee has not reported as yet.

Mr. HUNT. Mr. President, your committee to which was referred the report of the treasurer has carefully examined his accounts and find them correct. Vouchers are on file for the amounts paid out, all of which have been properly approved and receipted.

The report was accepted.

Mr. FAIRCHILD. May I ask for information at this point on an entirely different matter? When the reports of presidents of colleges was called for two years ago, the first report of presidents of colleges under the act of 1890, it was announced that the United States Government would consolidate, edit, and publish those reports. I would like to ask the executive committee if anything has been done or why it has not been done? The suggestion was made at the time the report was called for, that it be sent to the Commissioner of Education, the requirements being that reports of the president be sent to the Secretary of Agriculture and the Secretary of the Interior.

Mr. ALVORD. The chief clerk of the Bureau of Education is here and would probably be a better person to answer that question, and he may allude to it presently. I think I may say a word, however. I know that the Department of the Interior has the manuscript now ready for the press.

Mr. FAIRCHILD. May I ask still further on the same subject as to the law requiring these reports be distributed to colleges, a copy is to be sent to each college, I believe, but as yet we have never received such reports. What ought to be done by us in the premises?

Mr. HADLEY. In New Mexico we have the same difficulty that President Fairchild speaks of. We have just received from the printer both of our reports and they are now ready for distribution.

The PRESIDING OFFICER. The time has come when we should take up the discussion of the evening. Under the new Morrill act the colleges have been brought closer to the Bureau of Education than ever before. In view of this the Association has asked the Bureau to send a representative to discuss this matter. Further, we have made this Bureau a regular member of this Association. We have with us Mr. J. W. Holcombe, chief clerk, and I have the pleasure of introducing him for the discussion of the relations of the colleges to the Department of the Interior.

Mr. Holcombe then read the following paper:

3938—Bull. 16—8

THE RELATION OF THE AGRICULTURAL AND MECHANICAL COLLEGES TO THE
DEPARTMENT OF THE INTERIOR.

With so rich a program before the convention it is my duty to be brief and, in connection with the present topic, merely to suggest some of the points for discussion under "the relations of the colleges and the Department of the Interior," presenting a view of those relations from the side of the Department, and giving an opportunity for expressions of opinion to the men who administer the institutions themselves which receive the benefits of the several acts of Congress in aid of colleges of agriculture and the mechanic arts.

The first of these acts, that of 1862, which made the grants of land to the several States, can not be said to have established any relations with the Department of the Interior, as nothing more was required of that Department than the clerical duty of issuing patents and scrip for the location of the land. Even the requirement that an annual report be filed with the Secretary of the Interior has not been insisted upon by the Department and was generally lost sight of by the colleges. The act of 1887 for the encouragement of experiment stations makes the Department of Agriculture an efficient auxiliary and unifying influence in the work of these useful institutions, but gives the Interior Department no connection with them whatever. The act of 1890 appropriates certain sums directly out of the Federal Treasury, limits the application thereof strictly to certain specified subjects, and goes far beyond the previous acts in the definiteness and its requirements respecting the making of reports, their contents, and the time of filing them. By implication at least, if not directly, it requires a strict accounting to the Federal Government for the use of the funds received. Such implication is found in reading together the mandatory limitations upon the uses to which the fund shall be applied, the mandate that the Secretary of the Interior shall ascertain each year and certify to the Secretary of the Treasury respecting each State and Territory whether it is entitled to receive a share of the fund for that year, and the further mandate charging the Secretary of the Interior with the proper administration of the law. What facts can the Secretary ascertain upon which to decide whether a State is entitled to a payment? Surely no other than whether the funds already received have been applied only to the subjects named in the act of Congress. And how can he make certification to the Secretary of the Treasury, and otherwise properly administer the law, unless he can demand from each State full and complete reports, as detailed, as specific, as inquisitorial as may be necessary to satisfy his mind and conscience; that is, to satisfy the Federal executive power? A great and radical step beyond previous legislation must be recognized here. The land grant of 1862 amounted to an absolute gift. If the institutions established did not teach agriculture or military tactics (and many of them did not do so for years,) the President and his Cabinet and the entire judiciary of the United States might whistle to the winds for redress. But this last act establishes, to put it plainly, Federal control and supervision over the use of the fund created. If any dangers, therefore, lurk in the possibility of Federal interference and Federal dictation, the beneficiaries of this last Congressional grant are liable thereto.

Do we not remember, my hearers, a Will-o'-the-Wisp which led many a vain dance for a dozen years, the steps of which are marked by preambles and resolutions of national and State educational associations, county institutes and other teachers' meetings, religious conventions, synods and assemblies, and gatherings together of every character and description? Do we not all remember it, a delusive phantom now at last happily laid to rest forever: Federal aid to education in the States, familiarly known as the Blair bill. The Blair bill is dead, but this act of 1890 contains some of its features and other features of control which must in time have been added to any measure of Federal aid. What Congress would not do in reference to the general educational systems of the States it has done in reference to

a limited field of the higher education. The cordial acceptance of such a measure by the legislatures of all the States surely indicates that there is no real danger from Federal interference and that jealousy of the Federal power on that score has disappeared. At any rate we need not expect ever to see United States deputy marshals stationed in your class-rooms of economic science to note whether you teach protection or free trade.

But that there is a possibility of Federal dictation in this act is proved by the fact that our distinguished Commissioner of Education, a man who is most emphatic in his belief in State and local autonomy, was yet of the opinion that the words, "the legislature shall propose and report to the Secretary of the Interior a just and equitable division of the fund," gave the Secretary the power and made it his duty to sit in judgment respecting such proposed division. Thus the Secretary could oppose his opinion of justice and equity against that of a State legislature, and in one case the funds of a State were unfortunately withheld till a special act of Congress directed their payment.

But in this connection, let me say I deem it very fortunate that the Secretary of the Interior committed the administration of this act to the Commissioner of Education, rather than to a force of routine clerks in some division of the Secretary's large office. Thus was secured an inauguration of the act from, I may say, a sympathetic point of view with a comprehension of the conditions and needs of the colleges and of the new institutions which were called into being by the act of Congress. The Commissioner and his assistants in the Bureau hailed it as a step which would bring the Bureau of Education into vital relations with these valuable and growing institutions which have been justly called, and doubtless are, the true American universities of the future. It is hoped that the relations thus established may prove more and more helpful to the colleges as the years go by. In this hope the Secretary of the Interior, on the advice of the Commissioner of Education, has sent me to represent them both at this convention, to express their cordial interest in your work, their profound faith in the future of the American colleges of agriculture and the mechanic arts. The action of your association in providing in its constitution that a representative of the Department of the Interior shall be a delegate to your conventions with full rights and privileges of membership will be recognized by them with pleasure as a response in like spirit to their friendly advances.

There are two definite points to which I beg leave to invite your attention. One is the time at which treasurers' reports are to be filed. The law says September 1. Strange to say a few institutions did not have their reports in on time. Some wrote asking if a delay would make any difference, some offered one apology, some another. But, the language of the law being explicit on this point, the Commissioner will have to submit the question to the Assistant Attorney-General before venturing to recommend that any State where such failure has occurred be certified as entitled to the next installment of the fund.

The other matter is the form of the schedules for the treasurers' reports. This form, you will remember, was devised by a committee of this Association, in August, 1891, and was agreed to by the Commissioner of Education. But its sufficiency has been questioned by a number of treasurers themselves, and an experience of two years in handling the returns and conducting a correspondence about them has led me to doubt whether the present form of accounting for the expenditure of the grant of 1890 would stand a crucial test, which might be applied to it some time in the future. I will not go into particulars, as these are well understood by you, but will here leave the subject to be dealt with by the wisdom of the Association.

Mr. SCOTT. I suppose the paper is open for discussion. I have an engagement this evening, but am very anxious to say a word or two on the point last presented by the reader of the paper. In fact I may say

that was one of the main purposes of my coming here at this time. Last year at the convention this matter of a form of schedule for the reports of presidents of colleges to the Secretaries of the Interior and Agriculture seemed to me to be a matter of gravest importance and therefore in the section of college work I urged very strongly that the matter be taken up and that it be given into the hands of a committee then appointed for another purpose. This committee brought this matter, as has been stated by the reader of the paper, to the attention of the Secretary of the Interior, but it seems to me that the result is very unsatisfactory. The representative of the Interior Department has so expressed himself in his paper and I suppose he gives the official sentiment from that source.

I came here for the purpose, let me frankly say, Mr. President, of moving that a special committee be appointed to confer with the proper authorities at Washington for the revision of our form of schedule. No doubt we have begun our books in accordance with this schedule, but already the report comes from the Department that it is unsatisfactory to them and it certainly is to us. I therefore move, Mr. President, that a special committee of three be appointed to consider with the authorities at Washington the advisability of revising the present form of schedule for returns from treasurers of colleges.

The PRESIDING OFFICER. Gentlemen, you have heard the motion. Are you ready for the question?

Mr. ALVORD. I merely rise to ask whether this closes the general discussion. It only covers one point.

Mr. FAIRCHILD. I should like to have Mr. Scott go a little more into particulars and to designate what his idea is with reference to that schedule since the probability is that he will be chairman of that committee.

The PRESIDING OFFICER. We are all interested in this question.

Mr. SCOTT. Of course we wish to conform to the views of the Department first of all. The representative of that Department has not gone into details, and therefore I could not forestall any suggestions that should come from the Department. The motion, if the gentleman will recollect, is that the committee consider the advisability of revising; the Department will pass upon it. There are many particulars that might be stated here. It is most difficult in our bookkeeping to separate the articles. There has never been an official statement as to what is "stock," "materials," "apparatus;" so that it seems to me that this ought to be considered by this committee, that the proper classification should be made to conform exactly to the spirit and letter of the law, and a better classification covering the same ground covered here. I have no special schedule prepared.

Mr. PORTER. President Scott will remember that this question was fully discussed before the commissioner at the time, and all these questions were put to him specifically as to what they meant and a

strict interpretation as to their acceptation. Maj. Alvord was there and probably remembers the conversation. Unfortunately these answers were not put in an official form.

Mr. FAIRCHILD. I wish to express hearty sympathy with the idea of making a more exact report coming from the treasurers, that it be as accurate as possible in the statements as to what we have done with the money, and I wish to second heartily anything to enable institutions to meet the requirements of the law.

Mr. DEPASS. If I understand properly the motion of President Scott it is this: It is on the premise that the Department of the Interior has the right to say what kind of a report should be made, and that this is simply a committee appointed by this body to advise with the Department. The Department at last will decide on the schedule. This is a very reasonable request, and I hope the question will be put and we will let Mr. Scott keep his evening engagement.

Mr. ATHERTON. I would like to ask what especial difficulty Dr. Scott finds. There has been none with us, but I can readily understand where it might arise. I would like to ask Dr. Scott as to how the committee is to get at any judgment in consultation with the officers at Washington which will be any more likely to represent the interests of those present; that is to say, how will this committee when agreeing on something know that they are meeting the views of the Association? I do not see how we are to get any benefit from that plan. It may be just as unsatisfactory. I would like to suggest another plan. Why not submit the question to the executive committee? It seems to me that we should first have a consultation among ourselves and see where the difficulties lie and submit them to the Department. With all respect to Dr. Scott, and a desire to further this idea, I do not see where we will gain anything by this method.

Mr. SCOTT. The object is first to meet the views of the Department, as here expressed, that the schedule on which returns are now made is unsatisfactory. Let us have a committee to consult with the Department and inquire as to its views, and then have the committee obtain the opinion of the treasurers of the different institutions on the proposed form.

I apprehend the very difficulty before was that it was done in a hurry. Mr. Porter states that it was done after full consideration. We did not even think of it ourselves until the motion had been passed in the Section on College Work and the committee instructed to do certain work. It was upon a reconsideration that this matter was brought up at all. That being the case, I assume, further, inasmuch as the result has not proved satisfactory to the Department, that it was done without due deliberation. We have now had the experience of two years. The Department thinks it is not a proper schedule. I think gentlemen of the Association will agree with me that it does not fully answer our purpose. I therefore move that a special committee be

appointed, for, as the reader of the paper has pointed out, in these relations which we sustain to the Federal Government, it is all important that the matter of finances be properly adjusted in these relations. I brought no schedule here, nor do I think that this Association should do this in a hurry. It seems to me that it ought to be done by a committee specially appointed for this purpose to consult with the Interior Department and lay their judgment before the Association.

Mr. CLUTE. In view of the remarks presented by Mr. Scott, I am inclined to think that some action ought to be taken. I would suggest that the executive committee take charge of this matter supplemented with another name which I have mentioned. I move therefore to amend the motion of Mr. Scott, that the words "special committee" be struck out and the words "executive committee" be inserted, to which should be added the name of Mr. Scott.

Mr. ROBERTS. May I ask would it be in order for the chief clerk to give us some light on this subject as to the specific reasons why the reports are not satisfactory, if not out of order, so that we may understand more fully the difficulties met with at his office?

The PRESIDING OFFICER. We will be pleased to hear from the gentleman from the Department of the Interior.

Mr. HOLCOMBE. In this discussion I had proposed avoiding going into particulars or details, but I am able to give a few points. First of all I would say that dissatisfaction with this form of schedule was brought to our notice at the office by the treasurers themselves. I remember several very excellent letters from treasurers on this subject, one from Ohio, one from Nebraska, and a number of others which I do not recall at this moment. Treasurers generally find the difficulty mentioned by Mr. Scott in the proper classification of particular articles, which seems to show that these schedules are not adapted exactly to any convenient system of bookkeeping.

Now Mr. Porter referred to a conversation between the Commissioner of Education and the committee of which he was a member. I would beg the convention to remember that at this time the subject was entirely new to the Commissioner as well as to the consulting committee, and the Commissioner should not be held strictly to anything he said at that time. Most of the points which were brought out in that conference, however, the Commissioner committed to writing and printed in various circular letters sent out from time to time.

Let me say that in my opinion this form of account would not stand the test if applied by higher authority of the Secretary of the Interior himself. I mean that the act of Congress requires a detailed statement of expenditure. Now some Secretary with less confidence in the Commissioner of Education than the present one might appear on the scene and call for an exhibit of these reports and say, what articles do you suppose have been purchased under this head, stock and material, what articles under machinery and apparatus, and so forth and so on?

The Commissioner of course will have to say that that matter is left entirely to the treasurers and presidents of the institutions. That may not satisfy the Secretary of the Interior at all and there might possibly be some trouble on that account. I suggest this as possible, though I scarcely think it probable. Yet it would seem that there must be some tribunal to whom to refer questions as to what are proper expenditures. The Commissioner of Education has received many inquiries of that kind. Some interesting matters have come up in these reports, some rather amusing ones. Some gentlemen wanted to know why the Commissioner spoke of mistakes in statements in one of his circular letters. It was from the fact that a board of trustees of a certain college insisted upon purchasing a piano from this fund. The Commissioner held that he did not consider a piano a facility for instruction in any of the subjects enumerated in the act. The president of the institution had been of that opinion beforehand and expressed great satisfaction that the Commissioner of Education took that view of the matter. This is merely an illustration. Suppose the president of that institution, instead of corresponding with the Commissioner about the piano at all, had merely in his innocence said a piano is a facility for instruction in physics under the head perhaps of acoustics, the Department would never have known anything about the purchase of the piano. But if in any way the matter had become known, it would have caused trouble. These are merely illustrations of the point taken by the Bureau of Education, and I feel more at liberty to bring the subject before you from the fact that so many treasurers have expressed dissatisfaction with the present form of schedule.

Mr. HUNT. I would like to suggest to Mr. Atherton a point against referring this to the executive committee, and I do this because the secretary of our board of trustees would be here to-night if there was not a meeting of the board of trustees in Columbus to discuss this very question, and he asked me to present his views. I will have to speak frankly about it. There is need of a great change in this matter. Mr. Holcombe has mentioned receiving a letter from me on the subject. This question should be discussed by bookkeepers. A committee should be appointed of men making a special business of these matters and it seems to me that some such committee should be appointed, and I will say that if Mr. Scott had not made this motion it was my intention to do so. There are men in many of the institutions who have been there for the last twenty years and doing nothing else but making these accounts. They see things often that the college presidents overlook, and I think they would make more suggestions to the Bureau of Education because of this very fact. Our secretary wished me to make these suggestions to the convention.

Mr. ALVORD. There are two points to be considered in this question. In the first place when the present schedule was adopted, both sides in the conference between the Bureau of Education and the committee

agreed that it should be decided what was meant by the word "detailed" in the law, and there was unanimity of opinion and perfect accord on that point. There were present at that conference men who were thoroughly conversant with the system of accounts of college treasurers in every detail, and experienced in keeping such accounts. So much for the committee that brought the matter into this present shape. Now in regard to the revision. While I can speak only as an individual, the executive committee, gentlemen, has enough to do without seeking any further employment. If this motion prevails, I want to call attention to the fact that Presidents Broun and Goodell, and Director Neilson (who is treasurer of Rutgers College, of which Mr. Scott is president), are members of the executive committee.

Mr. ATHERTON. A word merely. I have no thought but the best way of getting at the desired result. If we feel as Mr. Hunt, that the committee should consist of bookkeepers, I would be glad to have the bookkeepers bring the result into the Association. My only thought is to get at the consensus of opinion so that when we make a change we will make a well-considered one. My individual judgment about such matters is that it is better to keep things of this kind in the hands of one committee, for the double reasons that we get the accumulated results of their experience, and secondly, officers of the Government come to recognize certain men as having a continuous representative quality and so deal more freely with them. You know how it is when you meet a man the first time—you take his measure as to how you will deal with him. I think it best to keep this in the hands of the executive committee with the understanding that the committee is to proceed very slowly and give results by correspondence or otherwise before taking any definite action.

Mr. TURNER. I think we may get a little practical information on this matter as we go along. The law requires that we should send a detailed report to the Secretary of the Interior. I would like to know whether the Department contemplates that when I give to a professor of chemistry \$500 for books used in his department every book is to be itemized in his report. Is that contemplated? I suppose there are 2,500 or 3,000 volumes in our library this year. If every book is itemized, and of course that is the only way the Department can know about the items, it will be an enormous work to be printed. I would like to know if it is to be carried to that extent. I will state how we do it. I have assigned to each professor so much money and each one sends in a list of books desired. The list is carefully revised and any book not coming under the scope of this bill is struck out. The list is marked and sent to the purchasing firm, and this list is returned so that there is no chance of a book being charged to the wrong account. But if all these should be itemized, it would be an enormous work.

Mr. NEAL, of Oklahoma. Another point I would like to make. I suppose our legislators when framing the bill organizing the college

were not very well posted in college matters. They have made a board of directors without assigning to the president of the board any salary. We have no funds except what we get from the Morrill bill, and have no salary to pay him. Another thing, we have a secretary and treasurer to be paid out of the Morrill fund. Where in the schedule shall we place their salaries?

Mr. HADLEY. I have been trying to get to say substantially the same thing. I suppose we will all consider that the prerogative of preparing forms for this report belongs to the Department of the Interior. The Department of the Interior is responsible for the distribution of this fund and I think it is equally clear from what has been said this evening in our own individual experiences that there is a difficulty in satisfactorily filling the blanks as now constituted. Therefore it seems to me that the proper thing for this body to do is simply to appoint a committee who shall stand in readiness to represent this Association in conference with the Department of the Interior if their services are invited, but not otherwise. That is just the way I feel about it.

Mr. WASHBURN. The Department of the Interior understands this matter to a certain extent and our executive committee is amply able to explain all these points. Therefore I move you that this be put into the hands of the executive committee.

The PRESIDING OFFICER. The motion is to refer this matter to the executive committee and have them take charge of it.

The motion was carried.

The question is now upon the original resolution.

The resolution was adopted and the matter left in the hands of the executive committee.

The PRESIDING OFFICER. The general subject is still before you—the relations of the colleges to the Department of the Interior.

Mr. SMART. I was a member of the committee to confer with the Department, and it was a most fortunate thing, gentlemen, for us that the Secretary of the Interior placed the matter in the hands of the Commissioner of Education. Perhaps Mr. Alvord has told you of it, but I will tell you again. It took a great deal of time and a great deal of pains to assist us, and I believe that the Commissioner of Education and his chief clerk are both entitled to our hearty thanks. I will not make a motion. I know that the mere suggestion of it will raise a response in the minds of those who know anything about it to give them our hearty thanks for what they have done. [Applause.]

Mr. FERNALD. I desire to make an inquiry. Under the act of 1862 we are in duty bound to make a report and send to the Department of the Interior. My question is, whether that covers the requirement upon the president of the college, or whether he should write out a separate report of the same matter to satisfy the provisions of the act of 1890, taken from the published reports.

Mr. HOLCOMBE. It is a close point, but I should say that one report is amply sufficient. Each separate act requires that the report shall be presented to the Secretary of the Interior, but one report would certainly be sufficient.

Mr. ATHERTON. Yet the Commissioner calls upon us for a second one.

Mr. SMART. This Morrill act requires a report of experiment work. It is a difficult thing to make a report covering experiment work practically duplicated in the station report to your Department. I want to ask whether or not the station report may be sufficient, whether that will be accepted or not.

Mr. FAIRCHILD. The law of 1862 requires that we report to the governor of the State and send to the Commissioner of Education two copies of that report. Then the law of 1890 requires that we report directly to the Secretary of the Interior and to the Secretary of Agriculture before a certain date. Now, most of us are required to make an annual report to the governor according to the laws of the States before the date on which we report to the Secretary of Agriculture and the Secretary of the Interior, the 1st of September.

I would like for this committee in conference with the Secretary of the Interior to determine this point. We have found the reports accumulating upon us from year to year, and it is almost impossible to keep track of them. Last year I made a full report to the Secretary of the Interior as to the expenditure of experiment station funds. I had already reported from the experiment station in full, according to the Hatch act of 1887, and was notified in last March or April that no report had been received in regard to the expenditure of experiment station funds. Of course it was my fault. I should have sent that other report at the same time. If they can take that into consideration I should like it very much.

I move, Mr. President, that the executive committee be requested to confer with the Secretary of the Interior with reference to a complete arrangement of the required reports of all the departments of the college, including the station.

The motion was carried.

The PRESIDING OFFICER. Is there anything further on the question? It is still open for discussion.

Mr. HADLEY. Inasmuch as we want to leave early to-morrow morning, I move that we adjourn as soon as the necessary announcements have been made.

Mr. ALVORD. I have a resolution which I am instructed by the executive committee to offer at the close of this discussion. Before doing so, I beg leave to say a few words on this general subject. I will simply refer to the cordial relations which have existed all along between the Secretary of the Interior and the Commissioner of Education in our mutual work under the act of 1890. Yet there has been one point on which I have radically differed with the decisions of the Department

and shall continue to do so, and believe the time will come when the decision of the Department on that subject will be reversed. The Department has declared under the act of 1890 that it was its prerogative to determine the division of funds under the Morrill act whenever under that law they were to be divided in any State. That has been the ruling, and under that ruling the act has thus far been administered. As a result, one State in this Union has not received any benefits under that act. The State of South Carolina, true to her general principles, believed that it was her prerogative to decide as to the division of the funds under that act, and has never reached any agreement with the Secretary of the Interior; consequently it has received no money under the Morrill act and has been so reported to Congress. In this one instance (and I desire to emphasize this) I believe South Carolina to be right in the position she has taken. I sat in the gallery of the Senate of the United States on a certain Monday morning prior to the passage of the Morrill bill. During a very close discussion, and just before the vote was to be taken, the Senator from Louisiana, Mr. Gibson, asked of Senator Morrill: "Do I understand, sir, as a result of this compromise, that it is left to the legislatures of the several States to determine how this fund shall be divided, if it is divided within the State, under the provisions of the act?" Mr. Morrill replied, "That is the amendment which I now offer to the bill." Then about an hour's discussion followed upon verbal amendments to the bill. When they were just about to take the final vote on the bill, Senator Cullom entered the Senate Chamber for the first time that day. He asked the stage of proceedings on the bill, and when told turned to Senator Morrill and asked almost the identical question put by Senator Gibson—whether the ultimate disposition of this fund rested with the Secretary of the Interior or the legislatures of the several States. Senator Morrill replied that it was left to the legislatures of the States respectively. Senator Cullom said, "That is not as I would have it, but I will interpose no objection now." The bill was then passed. Turn to the Congressional Record and you will find this substantially as I have said. There is no question as to the intention of the Senate of the United States and the point was not raised in the House. I believe that the ruling of the Secretary of the Interior is wrong, and I believe that the act entitles each State to decide under the act of 1890, and I trust the time will come when the act of 1890 will be interpreted in this respect as liberally as the act of 1862. While I have held adversely upon this point, I nevertheless have recognized that the best thing was to get the act generally into operation as soon as possible.

Mr. HOLCOMBE. I would like to call Maj. Alvord's attention to the fact that a special act has been recently passed by Congress authorizing the Treasury to pay to South Carolina the three installments due, notwithstanding the ruling of the Secretary of the Interior. The decision of the Department of the Interior has therefore been reversed on that matter.

Mr. ALVORD. I now offer the following resolution from the executive committee and move its adoption:

Whereas we recognize the great and increasing usefulness of the Office of Experiment Stations of the Department of Agriculture, in promoting the interests and efficiency of the experiment stations, under the act of March 2, 1887; and

Whereas a large and increasing burden has been placed upon the Department of the Interior and the Bureau of Education in consequence of the act of August 2, 1890, known as the second Morrill act;

Resolved, That while we recognize the cordial efforts of the Secretary of the Interior and the Commissioner of Education to administer that law so as to secure the highest benefits to the institutions affected, we earnestly request Congress to make adequate provision for the best administration of the additional duties placed upon the Department in consequence of the passage of this act.

Adopted.

Mr. ALVORD. It is understood under action already taken no more business shall be transacted at this general convention except to hear and act upon the report of the committee on acknowledgments and courtesies to-morrow evening.

The Association then adjourned at 10:20 p. m.

EVENING SESSION, FRIDAY, NOVEMBER 18, 1892.

The meeting was called to order at 8:40 o'clock by the chairman of the executive committee in Parlor P of the St. Charles Hotel.

On motion of Mr. Armsby, Mr Alvord was elected to preside over the session.

Mr. Stubbs introduced Mr. Higgins, proprietor of one of the large rice mills of the city, who cordially invited the members to visit his mills on Saturday morning before leaving the city, stating that it would not take over an hour and a half, allowing plenty of time for the early morning trains.

A census being taken as to the number desiring to go it was found that there were twenty-five. Mr. Higgins then said that he would be glad to have carriages at the hotel to take those desiring to go to the mills.

Mr. Atherton moved that the hour be 8:30, prompt, so that they would have time to catch the 11 o'clock train.

Carried.

Mr. Atherton then made a few remarks expressing the thanks of the Association for the many courtesies shown by the organizations of New Orleans, referring especially to the Southern University, and moved that a vote of thanks be extended to the officers of that institution.

Carried.

The presiding officer then called for the report of the committee on acknowledgments and courtesies.

Mr. Morrow reported the following resolutions:

The number and variety of the courtesies shown the Association which have made this meeting one of the most enjoyable in its history, make it impracticable to pro-

perly characterize and particularize each, and your committee can only make a bare mention of them.

It therefore reports that the thanks of the Association are due and tendered to the following transportation organizations:

The Trunk Line Association; the Central Traffic Association; the Southern Passenger Association; the Boston Passenger Association; the Chicago and Alton Railroad Company; and the Illinois Central Railroad Company for reduction of fare to delegates, and especially to the Illinois Central Railroad, to Capt. J. F. Merry, and others of its representatives, for the excursion to Baton Rouge, and personal attention in many ways.

Also to the local committee of arrangements, and citizens of New Orleans, for the excellent arrangements, especially mentioning the chairman of the committee, Prof. Stubbs. To the officers and faculty of Tulane University for the use of its halls and facilities for the meetings of the Associations. To the Literary and Social Clubs and Commercial exchanges of the city, and to President Nicholson and the faculty and officers of the Louisiana State University and Agricultural and Mechanical College for their hospitality at Baton Rouge. To the press of the city for its unusually full and accurate reports of the proceedings.

To Mr. Higgins for the cordial invitation to visit the rice mills of the city.

To the proprietors of the various sugarhouses visited on the excursion to Baton Rouge.

G. E. MORROW,
AUSTIN SCOTT,
H. W. WILEY,
Committee.

Mr. Smart, on behalf of Purdue University and other Northern institutions, extended an invitation to the Southern delegates to make them a visit on their way to or from the World's Fair.

The secretary then presented the following communication from the Iowa Agricultural College inviting the Association to hold their convention at Ames, Iowa, next year.

SECRETARY ASSOCIATION OF AGRICULTURAL COLLEGES AND EXPERIMENT STATIONS:

The faculty of the Iowa Agricultural College and the experiment station instructed their delegates to invite the Association to meet at the Iowa Agricultural College in 1893.

Respectfully,

HERBERT OSBORN.
L. H. PAMMEL.

The communication was referred to the executive committee.

The following resolution was offered by Mr. Goodell and seconded by Mr. Harris. Mr. Atherton made a few remarks, calling on the members of the Association to extend their support to this journal. The resolution was as follows and was unanimously adopted:

Resolved, That this Association, recognizing the importance of having a means of publishing nonofficially and promptly the results of agricultural investigation, and appreciating the value of "Agricultural Science" to all interests in that field, desires to commend that journal to the cordial support of all members of the Association and to the public generally.

Mr. HARRIS. I would like to say that the great delay in sending out card indexes prepared by the Office of Experiment Stations has been on

account of difficulty in getting the cards printed. This difficulty I believe is about to be surmounted, and I expect in the very near future to send the cards out quite rapidly. As soon as we receive the first batch from the Government Printing Office I expect to issue a circular in regard to the sale of the cards.

Mr. Cavitt, secretary of the board of trustees of the Texas Agricultural and Mechanical College, on behalf of that institution extended to the Association an invitation to hold their next meeting in Texas.

Mr. Miller, of the Maryland station, presented the regrets of President Silvester, saying that he had expected to come up to the last moment, when he found it impossible.

Mr. Alvord stated that several communications of like nature had been received by the executive committee from President Northrop, of Minnesota, President Stockbridge, of North Dakota, and President Walker, of the Massachusetts Institute of Technology.

It was then moved that the meeting adjourn *sine die*.

Mr. Alvord said that before putting the motion for adjournment he wished to express his gratification at the attendance and the work accomplished by this convention. It was the most successful in the history of the Association.

The motion being put, the Association adjourned *sine die*.

APPENDIX.

MINUTES OF THE SECTIONS.

THE SECTION ON AGRICULTURE AND CHEMISTRY.

The section on agriculture and chemistry held four sessions, as follows: At Tulane University, 7:45 p. m., November 15; 10:30 a. m., November 16, and 8:30 a. m., November 17; and at St. Charles Hotel, 6 p. m., November 17.

The first three sessions were presided over by Chairman Ingersoll and the last one by Chairman-elect Henry. There were seventy persons present at the second session, sixty at the third, and fifteen at the fourth.

On motion, Mr. Curtis of Texas, Mr. Gulley of Arizona, and Mr. Cooke of Vermont were appointed a committee of three to take charge of the program during the meeting.

On motion of Mr. Cooke, of Vermont, the section on chemistry was invited to meet with the section on agriculture.

On motion, Mr. Quick of Colorado, Mr. Thorne of Ohio, Mr. Georgeson of Kansas, Mr. Vanderford of Tennessee, and Mr. Roberts of New York were appointed a committee to report nominations for chairman, vice-chairman, and secretary.

The committee reported as follows: Mr. Henry, of Wisconsin, chairman; Mr. Stubbs, of Louisiana, vice-chairman; and Mr. Latta, of Indiana, secretary.

The report was accepted and referred to the general association for confirmation.

The following papers were read before the section:

Grass gardens—methods and purposes. By W. M. Hays.

Advances in farmer education. By W. M. Hays.

What should the professor of agriculture teach? By G. E. Morrow.

What should the professor of agriculture teach? By P. M. Harwood.

Grasses for the semi-arid region. By C. C. Georgeson.

The field of bulletins, present and prospective. By C. L. Ingersoll.

The physical tests of soils. By R. H. Loughridge.

The establishment of official methods of experimentation. By F. A. Gulley.

On motion of Mr. Scovell, of Kentucky, the paper by Mr. Loughridge was referred to the Association of Official Chemists for a comparison of the methods therein discussed.

On motion, it was decided that persons having papers prepared, but who were unable to present them on account of the lack of time, should hand them to the secretary for transmission to the committee on publication.

The following papers were thus received and referred:

What is the live weight of an animal? By H. J. Patterson.

Stock-breeding at experiment stations. By W. H. Brewer.

Methods of irrigation. By L. G. Carpenter.

The press bulletin. By C. E. Thorne.

Fiber production. By Charles R. Dodge.

GRASS GARDENS—METHODS AND PURPOSES.

By W. M. HAYS, *of North Dakota.*

The purposes of grass gardens on experiment farms may be named under several heads:

(1) The teacher who has students interested in agriculture, and can have their attention while grasses are growing and fruiting, needs small plots of all the economic grasses, clovers, and other forage plants, where he can require each student to make himself familiar with their economic and botanical characters. Not a little of the much needed concrete teaching of practical things can be accomplished along this line by the energetic teacher. Such work as requiring each student to keep notes on one or more plats of grasses or clovers during one or more seasons would be of use to the boy when he becomes a farmer. The student who learns to compare the yields, time of ripening, fighting proclivities, methods of seeding, and other economic features of the most useful grasses of his State, by observing them in adjacent plots and especially by systematically recording notes on them, has a most useful fund of information. It is a kind of training almost as hard to get by means of lectures and text books alone as it would be to become a chemist without laboratory practice. A student thus trained is able to treat field conditions on the farm from the standpoint of technical knowledge. At the north there is a serious obstacle presented to the above plan. The plants in question nearly all flower and mature while the students are away from the colleges during the summer vacation. Students should all be expected to preserve botanical specimens of all economic forage plants suited to their State and garden plots will greatly assist them.

(2) Whoever carries that part of the teaching which relates to the cultivation of crops, their rotation, management and thus keeping up the fertility of the fields needs to have charge of and require himself to keep notes on plats of forage crops. The teacher of general agriculture in those Western States where mixed farming is practiced and much live stock is kept especially needs to keep himself posted along this line. The teacher who will do this work and by traveling, inquiring, answering questions and in every possible way try to become expert in the management of pasture and meadow crops, will be able to make himself as well appreciated as the professor who, by becoming an expert in live stock, gains the confidence of the stock-raisers.

(3) The grass garden furnishes the place and methods for testing foreign or new varieties of annual and perennial forage crops in a less expensive way than would be possible in field plats. Promising things alone need be taken to the field to give them actual trial in the economy of the farm, or distributed to farmers and others who will coöperate.

(4) Preliminary tests of grass mixtures can be carried on in comparatively small plats. These can be planted in duplicate and thus tested under the different conditions furnished by sowing at different times in the season, in different seasons, on different soils, on lands differently prepared, sowing with or without another crop, covering the seed in different ways, with and without top dressing. Under all these conditions the power of each perennial variety can be studied as to its length of life, its power to hold its own in competition with all others, the amount of and proportion of forage produced by each plant in the various conditions, and in the various

mixtures. The lessons the careful experimenter will gather while systematically keeping notes of a series of plots are without number. He may get many weights of products which will give him a basis for formal reports, and he will learn the general facts and laws governing rational practice in the region for which he labors. The most successful plans can be extended to field and coöperative tests or possibly recommended for trial by farmers.

(5) Probably the most important work to be carried on in the grass garden is that of the improvement of the standard grasses and clovers which are of such immense importance in our agriculture. No one thinks strange that pansy fanciers and propagators go to the trouble to improve pansies that they may have rich and novel combinations of colors. But who has even carefully studied out the variation in the plants of timothy or red clover or other varieties upon which so many of our people depend for sustenance and means of obtaining the enjoyments of life. Who can tell us as to whether material improvements can easily be obtained by simply selecting the best plants of timothy for a number of generations. Who among us is really reaping for the farmers the fruits of the seed sown and the harvests of fame made possible by the great work of Charles Darwin. He showed us how by crossing plants carrying distinct blood lines yet close enough to unite that we could increase productiveness and by selecting desirable variations we can secure sorts which better suit our needs. We are not keeping apace with our horticultural brethren who are cross-fertilizing apples, grapes, strawberries, and many other classes of plants.

A few other facts as to methods of work in the grass garden may be classed as follows:

(1) The size of plats to lay out for varieties must be determined by the purpose in mind. Plats 1 or 2 yards square with alleyways 2 to 3 feet wide are suited to the purpose of the botanical study of species, and on these small plats many practical questions as of annual or perennial habit, ability to withstand the encroachment of neighborly species, or the time of season when the main growth of pasturage is produced. Plats 20 by 20 or 20 by 40 feet, in which 1 or 2 square rods can be harvested without taking the border, is a good size to study yields, as weights can then be at once taken on portable scales. All plats for this purpose must have duplicates, the number depending upon the uniformity of the land, care in producing and planting the seed, etc. Plats of this size will also do for experiments in comparing grass mixtures, though larger ones for all but preliminary trials are advisable. Perennial plants should be so distributed in the plots that those nearly alike are not on adjacent plats, as mixing will thus be a less vexatious matter. Planting in close rows instead of broadcast is conducive to economy, ease of weeding, and ease of keeping from mixture of kinds where not desired. This plan is sometimes objectionable, as it gives the plants unusual conditions.

(2) Where sown in drills small plats can be weeded as long as is needed the first season. Where sown broadcast all but very rank growers can be insured a better chance than they would have in field practice by mowing the weeds occasionally at a height of about 3 or 4 inches. For some purposes it is wise to sow the plats to wheat or other grain and then seed the grass before or after the last harrowing, or in early spring with winter grain, as is the custom in field practice. Some stubble, aftermath, or even weeds, is oftentimes a good winter snow gatherer and protection.

(3) A complete history should be kept of the plat. Source and quality of seed, previous treatment, preparation and character of soil, time and manner of planting and amount of seed, time of coming up and fullness of stand, and favorable or unfavorable weather, are all parts of the plat history to be recorded the first month or two. Changes in stand of plants and their cause of decrease, development as observed at stated times, time of flowering and seeding, when large enough for pasture in spring, whether annual or perennial, time harvested, green weight and dry weight per acre, time aftermath is ready for pasture, relative amount of fall pasture, time it succumbs to frosts as compared with some standard as red clover, etc., etc. I have

kept grass plat records by giving to each plat one or more pages in a note book and write into this the notes as made in the field. The facts are then all in chronological order when the plot has run its course, or at any time they are needed for study or report. Having the previous history before the eye at the time of making additional notes is a help. Note books of tinted paper are less severe on the eyes for taking notes in the sun.

(4) The first thing to be done in taking hold of a variety to improve it is to study the plant's method of reproduction, as to whether close fertilized, its variation in such economic features as size, earliness, yield of seed, ability to spread rapidly by stooling, if a grass, as to whether long or short lived in those like clover, which are little better than biennial in habit. I have a variety of timothy started with which I am much pleased, both because it promises to be good foundation stock upon which to work by means of selection in the production of larger yielding varieties, and because the distinguishing mark found in the sport I started with seems easy to perpetuate and fix as a permanent variety mark. The spikes are branched, having on either of two sides several spikelets which stand out one-quarter inch or more, being that much longer than the other spikelets. I have also white flowered *Trifolium pratense* raised from the white sports often seen in fields of red clover which promises to serve as an excellent foundation stock from which to develop varieties of clover by selecting for intrinsic qualities, at the same time making the unusual color a distinguishing mark. In the case of clover cross fertilization and selection can be taken advantage of as well as improvement by selection alone. Timothy flowers are rather small for the patience of the ordinary man to try to cross them artificially, though not impossible.

ADVANCES IN AGRICULTURAL EDUCATION.

By W. M. HAYS, of North Dakota.

The country district school furnishes the bulk of the school education of the rural youth. By attending for a year, more or less, at our excellent city high schools, academies, colleges, and universities many of those who continue to reside on farms receive further school education and culture and gain many technical facts useful in their lives and business. Our whole systems of secondary and higher institutions of learning are in fact doing an immense work in educating farmers as well as other classes. The influence of the literature of books and periodicals and of public speaking and of private discussion are wonderful factors in moving forward the powerful mind forces of our agricultural people.

Technical farmer education took on form in periodicals and in speech making and with the land grant of 1862 in schools. These journals have grown into hundreds of general and class papers, with the fifty experiment stations making copy for them. They have also a constituency of agricultural specialists, who supply a never-ending stream of useful facts. We may have too many papers; but, as with cattle, when there is a surplus it is the scrubs which must go, even if by means of score card and record the farmers must find means of making a division. We need more editors and more publishers who have an agricultural college education. All here have little need of a recital of the way most agricultural colleges started with their course of study more scientific than was found in literary colleges, and with a minor amount of agricultural subject-matter. The science was generally well taught and was popular with the students in these colleges. Most of the men who taught agriculture had never learned the business of teaching in these lines, and whether they were scientists merely, simple practical men of farm affairs, or even in some cases where they had good qualifications, as things then were, in both science and practice, they pretty generally found a great load to carry, or even could not see far enough to find the load that should be carried. In too many cases students found that agricultural subjects were not taught in a manner to fully satisfy them.

The agricultural technique in these early attempts was often left to one man, as much through his fault as that of the teacher of mathematics, who may have had a needed assistant. The poor professor of agriculture struggled on, carrying instruction in live stock, dairying, soils, crops, horticulture, forestry, veterinary, and if really unlucky he consented to take botany and entomology also. The man who tries to carry even a few of the most allied of these lines has not the highest success in really educating his students. The plan being carried out by the Wisconsin, Michigan, and other schools, where there is a specialist in each of the several divisions, of what the professor of agriculture was formerly expected to teach, seems wise and brings results when practiced in school work and in station work as well.

These colleges have been successful scientific institutions from the start, but their evolution into schools of agricultural technique and practice has proven a longer and more painful operation than was dreamed of in the start. Some institutions are on a better basis than others, in that they have one or several successful features worked out under their own experience, and in their own way. Since the experiment station fund increased the study of the technicalities of practical farm affairs, there has been a general division of labor and increased interest, which has resulted in much experimenting and upbuilding along the lines of arrangement of course study, and of the subject matter taught by teachers in lines generally allotted to the agricultural department or division in the colleges. There is a strong disposition and effort everywhere to not only thoroughly prepare a lot of men well equipped for professional agricultural men, but to secure students who will return to farms, and to give them a training for their future business that will simply lead them on and not away from the farm. We have no one institution to which we can point as a model for other States, or even for its own State. We can, however, point to some rather new features in various institutions which are apparently very valuable experiments, often successful ones. We have new arrangements of courses of study, like the dairy schools of Wisconsin are, in Minnesota and other States. Short winter or farmers' lecture courses, the school of agriculture, as in Minnesota and Missouri, and doubtless other rearrangements more or less supplemental to the original straight four years' college course. These experimental courses and schools have grown up to meet a demand coming from the people, or a dire necessity on the part of the institution to accomplish something, and are of far greater moment than many experiments in our stations.

The agriculturist's work, so far as what he shall teach, and how he shall teach it, depends much upon the class of students he has, and what they are expected to do with their training. It is not the main duty of a college and its professors of agriculture in a given State to make, by encouragement and special instruction, a lot of agriculturists, dairy teachers' and live-stock instructors for the home institution and those of other States, though that is a very important secondary line. The main great duty from this on of the division of the work his department represents is, I believe, to educate young men who will farm and become models for their neighbors and teachers of others. Thirty per cent of those who enter is enough to have choose other professions than farming. These colleges of necessity had to educate men to be teachers and experimenters during their earlier history, and greatly to be honored are these States which have sent out in other States so many useful men. The production of these men must be continued, but hardly as the over-topping object of each institution. These men who are fitted as specialists are largely a means to the two ends of teaching and experimenting, and we must depend upon this class largely for the men who, by experimental research, shall develop and broaden the sciences of agriculture.

The other purpose of the college is to give to the would-be farmers education in the farming business. I realize that I have taken radical ground, but the change wrought in Minnesota by a school experiment heroically tried there has converted me into this belief. Dr. Porter, who helped start the idea and movement there, has

so much faith in it that I see he is developing a similar school in Missouri. The two years' school of agriculture course in Minnesota, instead of degrading education, has become the pet of the farmers of the State; and the faculty and students of the collegiate department of the university of which it is a part are also proud of it. It is a school to meet a certain purpose, and it fills the place for the young man who will be a farmer much as does the high school, the business college, or even a law school for the general business man or the lawyer. So the dairy course and the farmer's winter course fulfill each its distinctive purpose for some dairymen and farmers who want to attend the school only for a short time, as does also the college course meet the wants of the young man who wants the broader culture of a college course before taking up the management of his farm, or the one who wants to pursue the professional work in agriculture.

To really carry out the suggestions above made, that we come down from our high perch and teach the farmer what he wants, not a little depends upon the several men who teach the division usually distinguished as agriculture, including, of course, horticulture. Young men who have grown up into practical farmers, who keep in touch with the work at home during vacations, and who are at the school largely as a business venture, count largely upon what they get in this division to help them in their work when they go back to the farm, and many of our former short-course students have confirmed the truthfulness of the above assertion by so stating a few years after their return to their business. There is great inspiration, too, to the teacher who gets close to these boys' lives and purposes in the questions and pointers they will give in class and when working at practicums; also when they return after a year or more on the farm since leaving the school.

We have no one institution to which we can point as a model for others to follow. What would be best in one State would hardly fit any other. But we now have ample examples of successful features of various colleges from which any institution not in satisfactory condition can select patterns with which to add to or reconstruct an almost model institution in each State; and further experiments that must result when we supplement the four years' course will add more successful features from which each institution may select. True we have not had enough men who have had successful experience in the various technical lines to man so many model institutions with model teachers, but these men are rapidly being made. The raw material comes generally in full stature from the farm, and are being molded by special courses and secondary courses, dressed by collegiate and graduate courses, and kiln-burned to a finish in the useful function of assistant college and station workers. Some of them stop underdone; others come out overcooked, cracked, or warped, but there will be sufficient of the true-rounded cylindrical-shaped who will fit together, and through which the clear, filtered stream of agricultural thought will run from the soil to the spring where the farmer can drink from the crystal fountain of knowledge.

A review of the present development and differentiation is in order. Colleges like that in Wisconsin have grown from the one-professor idea to a position where a dozen or more men work in as many lines which apply to practical agriculture. These men leave to other college or university departments the general fields of science. Even the lines of agricultural chemistry and agricultural physics are there being more or less divided to separate men, and two or more men represent as many parts of dairy manufacturing, and as many more dairy stock. Close division of labor all along the line is absolutely necessary. These close specialists are bound to make their work go. They will evolve text-books, methods of practicums, and other indispensable machinery of farmers' educational work.

The several purposes now being looked at in one or all the many colleges may be classed under the following heads:

- (1) The general education of men, because they are men.
- (2) The advancement of sciences which underlie industrial education. The Government assisted the States to make provision for these general classes of work

elsewhere. Agricultural college funds are nowhere sufficient to carry even agricultural work and that in mechanics, which rightfully belong to these institutions. If we can get talent to profitably use the funds to help people, part of whom will return to their industries, there is where most of the money belongs. Much, however, has been done along these wider lines of education.

(3) Technical science, the object of which is to amass facts and develop appliances and men who shall work along industrial lines, I place in this class.

(4) In the fourth class I place special schools, as of dairying, practical mechanics, veterinary, domestic economy, etc.

(5) In the fifth class I place the schools of agriculture and short courses, which are adapted to the wants of the young men and young women who want an education of the high school, academy, or business college grade before settling down on the farm. These last-named schools fit most of our business men for life, as do the schools of medicine prepare doctors; and schools for farming, not necessarily schools for professors, will likewise fit our farmers to keep up with the agricultural procession of their generation, and it is nearing the two-minute gait.

(6) In the sixth class I place farmers' institute and allied work as a most valuable part of the college. Here facts can be given the farmer interested in the broader, more complete work of the school courses.

(7) Possibly some organized attempt would attach rural district schools in some way to schools of agriculture. This might allow of some agricultural lessons to be taught in country schools, and some stimulus to make the country school prominent as a stepping stone or leading string into these agricultural schools of a secondary grade.

If we fill up our schools of a secondary class and there present a course of study of which the returning farm boy will speak in the highest terms to his neighbor youths, we will find plenty of students interested in getting on a better basis before settling down at farming. You might even get so many of these short-course graduate students that those who would continue in the college course, plus those who now enter from high schools, would far outnumber your present number of college students and graduate students. You thus increase the popularity of the college course and besides do the work that farmers would now at once demand you must do if they thought you could do it. That boys can be taught much of how to live in a two-year course, as well as much technical knowledge, I have seen as clearly demonstrated in the case of students in Minnesota as I have learned that many colleges lead from the farm.

INTRODUCING NEW FEATURES.*

So far as the immediate school education of the to-be farmers was concerned, our colleges of necessity began at the wrong end. They did not well know what was wanted. The farmers generally agreed that schools as thorough as any needed by professional men must be supplied to farmers' sons, who of all men need and are worthy of a knowledge of many things. The school men who had charge of affairs naturally were ambitious to have high collegiate courses of study. In getting ready teachers and experimenters and in developing the science and education, they have done wonders. Several have made an especial effort to get as many men in other stations as possible, not always regarding quality as much as should have been done. It strikes me forcibly that we now have reached the point where a strong push can be made to turn part of these developed forces into channels which will bring hundreds of thousands of the future farmers into the popular systems of instruction in schools of agriculture.

The force of inertia, where conditions exist which seem stable, is the greatest obstacle. Votes and personal work of farmers have been tried successfully in some States. Should Prof. Henry, here, get into position to show and tell through the papers that he has 1,000 students in his short courses and that he had been asked by

the State to put up more buildings to accommodate more sons of the constituents of the State legislators, the farmers in other States would find it out and would see that similar plans were followed in their own institutions. The more natural way will be for the people in authority to master the new ways of doing things in the various institutions and adopt as rapidly as things adapted to their several States prove themselves of merit, or even really promising. Every college ought to be trying one or more of these experiments, and we would soon solve the great problem of how to have farmers who are educated in their business.

The things needed to make these ventures successful are faith, plans, courage, money, equipment, and men. Most of our colleges need double or treble their present income to make their work successful. Beet-sugar factories are not successful on a small scale. They must have a capital of \$200,000, so that all parts can be built up in the most approved and best way. A few professors with a small equipment can not satisfy students, unless quality makes up for quantity. I once had a pet idea that a number of agricultural schools in each State would be far better than one college, but experience teaches that a large equipment is necessary.

Wisconsin and Minnesota stand very low in the record of the number of station workers and teachers they have turned out. But if you want to see the kind of men farmers want our colleges to turn out, go to Mower or Renville counties, in Minnesota, and find some of the graduates of the school of agriculture. If you want to see the kind of butter and cheese makers the farmers want produced to manufacture their dairy goods, go into many factories in Wisconsin and find men who have been at Madison. You will be able to find in the homes of this same class of farmers model wives, educated in the domestic-economy schools of agricultural colleges. What other class of institutions can or will take up the development of farm women's technical education, as well as domestic science for all classes of women? Science has been more tardy in helping agriculture than any other great industry, and even yet more tardy in helping woman in her work.

MINNESOTA'S EDUCATIONAL SYSTEM.

As there is no representative here of the School of Agriculture in Minnesota, I have been requested to make a statement of its plan. The agricultural college is a part of the university. While the university was struggling along during the earlier part of its history, there was little demand for the college course in agriculture. The wheel horses at the head in its management lost faith in the possibilities of agricultural education, and as every dollar told in other lines there was for a time a tendency to let the work sleep and not even have the one professor of agriculture. Pressure from without and a constant demand for separation caused the authorities to hunt for something practical to do. Prof. Porter was called to the institution and started a summer school of practice, but wanted something better. State Supt. Kerle, *ex officio* a member of the board of regents, was sent on a tour of inspection to the most successful colleges and university departments. Some things were learned at Guelph, Canada, as well as at other schools.

The farm in the city by the university had become very valuable real estate and was sold. A better farm 3 miles out and some good buildings were the returns from the sale of the first farm. On this farm the station corps was located, and a school of agriculture was started the same year, providing for a course of two winters of six months each. This was afterwards extended to three winters of six months each. The farm boy can do but little in Minnesota during the long, cold winter, and he can go there as cheaply as he can attend the local high school or go in society at home. Forty-five students were enrolled the first year. The next year we had 75 students, as I remember, and agriculture, horticulture, veterinary, dairying, live stock, and carpentry formed a large part of the instruction. The school, now in its fifth winter, will register considerably over 100, and would have been much larger if the employment of a greater number of teachers had made the instruc-

tion better along technical lines, more practicums provided, and other improvements earlier made. This school has now settled down to the plan of about one-half the students' time being occupied with common and high school studies and the other half the lines named above. Where a student is well up in general studies, he devotes his whole time to technical subjects and sooner completed the course. Great credit is due the principal, Mr. Pendergast, and his assistants, professional high-school teachers, who have taught the general studies and, living with the students in the dormitory, fostered the school and farm spirit, the spirit to make the school prepare for the farm life and work.

These young men are enthusiasts over the school. Most of them do not expect to go to the university, and, though bright, are boys most of whom would not be led through the usual high-school channels to get into the university or other college courses. They are mainly boys who have fully decided to make farming their business. Half a dozen of the fifty or sixty students who have finished this course have entered the college course, to which they are barely prepared to enter upon graduation from the school. Probably all but one of this number will hold to agriculture. All the other graduates, with possibly a few exceptions, have gone back to the farm or into an allied branch of farm business, as creamery management, nursery management, etc. The greater number of students who entered the school and took one winter's work, more or less, selecting out a lecture course, with possibly one or more other studies, have practically all returned to the farm. Of the agricultural college students, one is a junior, two are sophomores, and three are freshmen. They enter the freshmen university classes with somewhat less training than do the high-school graduates from Minnesota's excellent high schools, but with a prestige of practical acquirement and industrial importance that makes of them peers of their literary and scientific fellow students. These young men tell me that they are consistently and respectfully treated by all students. These men are all taking the agricultural, though others now in the school are expecting to enter the excellent mechanical college of which my friend here, Prof. Hall, is dean. They can enter any university four years' course from the school of agriculture.

The entire instruction of the students in the school is provided at the experiment farm, part by general teachers employed for that purpose alone and the technical part by the experiment station workers. The students in the four years' college course have all their general science, literature, etc., in the city in the regular university classes. Four terms, when they can best leave the regular classes, they move out to the experiment farm and spend their whole time receiving technical instruction from the experiment station workers. These college students, having gone through the school, have a great interest and pride in doing it every possible service and help to keep up the farm spirit. The policy of the teachers on the farm has not been to make any special effort to induce graduates of the school to take the college course. Occasionally a young man who seemed especially fitted to professional work was advised to take the advanced course with that in view.

ADVANTAGES SECURED.

Several things have been accomplished in Minnesota. First and best, expert farmers, horticulturists and dairy workers are put out as leaven in the State. Second, the farmers are interested, aroused and desirous, and more hopeful for more farm school education. Third, the institution has gotten into good repute, entirely revolutionizing public sentiment, and surely can secure money more freely. All this was helped by Supt. Gregg's farmers' institute. Fourth, the whole institution is alive to making agricultural education successful. The school of agriculture has brought the course in agriculture right down where the farmer boys can enter even from frontier counties, where school facilities have been meager. It has enabled the college to raise the collegiate standard for entrance, thus bridging over the gap between country schools to even a higher point than can be reached in the colleges in the

older States, where students come better prepared than in the West and South. It thus makes it possible to raise the standard of that important course which makes teachers and experimenters.

Several classes of students are here provided for. The man who wants a winter lecture course can select from the school of agriculture. Students who need to unite general school work and technical instruction can take part or all of the school course and even continue and take part or all of the college course.

Those who want to take up professional work take the school course and then the college course, thus putting in six years, not being able to get through without being well prepared, so far as school work can prepare a man to teach or experiment.

THE BULLETIN, PRESENT AND PROSPECTIVE.

By C. L. INGERSOLL, of Nebraska.

In opening a discussion of this subject it is done with hesitation, as I fear I am treading on ground that is dangerous; that some sensitive worker upon some of our stations will imagine that some well-directed remark was intended for him or for his station. However, the present bulletin of the average station may, to our notion, be much improved for the average farmer reader. We must remember first of all that of each issue quite a large number will very likely read a bulletin for the first time; therefore, as the first proposition, I would have—

(1) Simplicity: Let the whole description be clothed in simple language, and, when necessary to use a technical term, then in parenthesis give a very plain explanation for the benefit of all. Some bulletin-writers seem to have forgotten after two or three are prepared that they are progressing rapidly by their constant association with and study of experimental work, and that their constituents do not from the very necessities of the case go nearly so fast in the matter of improvement and education. This caution will apply to nearly every person who prepares bulletins.

(2) Completeness: Each bulletin should, in our opinion, be complete. Do not refer in a bulletin to three or four previous ones in a set. These bulletins may fall into the hands of those who only have the one before them or they may not have preserved the previous numbers. If necessary to completeness then, explain in as few words as possible the point alluded to, so that the reader may not turn away disappointed, having lacked in finding that which possibly gives a clew to the correct interpretation of all the rest.

(3) Graphic illustration: Whenever possible it is of great advantage to show relative values, yields, etc., in graphic form, so that at a glance one may see the general results, without searching through long tables of figures. The same matter may be presented in other forms in the conclusion. The value of this arrangement can not be overestimated. Then, too, illustrations in the way of photo-engravings of matters of interest add very much to the accuracy of the information conveyed, as well as being of more than a passing interest to the reader.

(4) The conclusion: By all means have a well-digested conclusion, with the important points and figures well grouped, so as to make them easily remembered. The busy man has no time to look into the detail, but he will look over the conclusions you have reached and agree or differ with you in thought quickly. It is his way of doing business. The farmer, who, weary with his day's labor, sits down for a half hour in the evening, is in no mood to take up anything that needs much application; he soon tires of it, nods, and sleeps. But the brisk and brief conclusions of an experiment in which he has an interest he will read, and this may arouse a degree of interest sufficient to induce him to lay away the bulletin for more careful study and possibly for preservation. He may even caution the family not to touch that bulletin when they look for material with which to start the fire. All of these things have a bearing. Let us then spend time to make a careful and interesting digest of points grouped under the heading "Conclusion."

PROSPECTIVE.

Will the persons receiving bulletins become educated so that the standard may be raised soon? We believe not. If we look in advance a period of ten years we do not believe that the average reader of bulletins will become educated so that the writer may use technical terms in chemistry, botany, horticulture, physics, and geology *ad libitum*, but we must constantly be on our guard, remembering for whom we write, for whom we labor.

The temptation of the scientist is to do something which will give him a name and a place in science, a reputation. It is a laudable ambition and we admire it; but at the same time it does not hinder our putting things in plain terms for the masses. Reserve our technical papers and researches for our associations for advancement of science, for the scientific magazines, and for our brother scientists generally. There are a few, however, who take the other side of the argument, and say that, if we make our bulletins simple and plain, ourselves and our work will be judged accordingly, but, if we put out learned bulletins, the people, not understanding the full purport, will rise up and say en masse: "What a smart man and what a learned production!" Persons may be found fulfilling all the conditions named and still others. These illustrations will suffice.

Of minor points we suggest a few, by way of emphasis only. The outside of the bulletin should have printed upon it the title, date, station, and all other data necessary for one to note at a glance all the facts connected with the issue.

For ourselves we would prefer to see the writer of the bulletin named upon the outside and not the director, president of the college, or other officer in charge. The station staff can be published on the last leaf or inside the cover. Then, too, the matter of numbering should be uniform. It has become beautifully diversified at present. It seems to us that if any one thing should come under the purveyance of the Department of Agriculture it should be the numbering and arranging of these in some uniform manner for future finding and reference, and the year 1893 would be an excellent time in which to begin the work. The form has not been uniform in size and shape, and the volumes, when bound, will present a heterogeneous collection. But these matters have been urged upon us from time to time, so that one need not go astray. The difficulty arose in the first place from each station starting out in its own way, and then each desired the others to come to its way of doing things.

The quality of paper in many instances is poor, and this detracts much from the value to the recipient. If it is on good paper, put up in good form, and is neat and attractive, it is liable to be preserved. If it is sent out on cheap paper, is poorly printed, and otherwise like a very cheap newspaper, it will be treated as all cheap circulars are treated; it will go to the waste-paper basket with scarcely a passing notice.

In conclusion, let us study carefully the problem of how to present the work of the stations in order to do the most good. The workers are as a rule conscientious, energetic, and are doing a large amount of work in the aggregate, in which 65,000,000 of people are interested. Nearly one-half are directly interested as agriculturists, stockmen, horticulturists, and gardeners. The others are indirectly interested in seeing the first half prosperous and happy.

Remembering this fact, then, gentlemen of this Association, let us strive earnestly to improve upon the work of the past; let 1893 be a year of marked progress in the bulletins of our agricultural experiment stations.

WHAT SHALL THE PROFESSOR OF AGRICULTURE TEACH?

By P. M. HARWOOD, of Michigan.

The position of the professor of agriculture is unique and is an extremely difficult one to fill. Not only is he called upon to perform the threefold duties of professor of agriculture, superintendent of the college farm, and agriculturist of the station, but the ground he has to cover in teaching is so large and of such diversified nature

that it can be treated only superficially at best and is more properly the work of several men, each an expert in his own department. Then, too, he has to deal with a class of young men who, as a rule, come to the college but poorly prepared to take up the work and carry it on successfully. Indeed, it is extremely unfortunate that agricultural colleges are obliged to teach so much that is merely fundamental in its nature, much that might be far more economically obtained at home in the common and high schools; but, taking agricultural colleges as they are, some located in dairying sections, some in grain, and others in cotton growing States, some well-endowed and equipped, large, strong, independent institutions, others parts of universities, where they are more or less overshadowed and restricted in their influence, it is hard, nay, well-nigh impossible, to say what the professor of agriculture shall teach and have it apply to all cases. Representing, as I do, one of the oldest, largest, and best equipped of the agricultural colleges of the country, it is, perhaps, but natural that I should look at this question somewhat in the light of future possibilities, and, at all events, in the light of an all-around agricultural college.

What shall the professor of agriculture teach? My answer, in one word, is agriculture; in two words, practical agriculture, and never, under any circumstances, anything else. Specialties like dairying, cotton-growing, grain-raising, and the like will each take precedence naturally in the localities where they belong. But in a college like the one in Michigan no one line will at present take a long lead over another, but the whole ground has to be covered, so far as the agriculture of that region is concerned. Already the duties of the head of the department are those mainly of an executive officer, whose duty is to superintend and direct instruction rather than to teach; also to superintend the farm management and the agricultural experiments at the station. In the matter of teaching, we first separate the great subject of agriculture into its two natural divisions—vegetable economy and animal industry—and each of these subjects is taught by an assistant, who is a specialist. As the department grows, as it is certainly destined to do, subdivisions of the above will have to take place and other assistants will have to be employed, and thus the work done in the department will develop and improve in value as time goes on and more money becomes available for the work. The ideal instruction towards which we are all working, I believe, will be given only when there has been a perfect division of labor and each and every branch of agriculture is taught by experts.

I have said that the professor of agriculture should teach practical agriculture. I want to emphasize that. This is a practical age. Education is for the development of the mind. Agricultural education is for the development of the mind along agricultural lines. Our object is, or should be, to turn out practical farmers, not in any narrow sense, but men with all the advantages of trained minds and trained hands, to fill honorable places in life and withal to be prepared to compete successfully and creditably with others engaged in the same calling.

The college graduate ought, with these advantages, to get more out of life and above all out of his business than he otherwise would. If we fail to turn out such men, we fail in the prime object for which our agricultural colleges were established and for the maintenance of which many thousands of dollars are being spent annually. Science is all very well, but unless scientific truths can be taught and the practical application made clear so far as turning out practical agriculturists is concerned they would better not be taught at all. No professor of agriculture is a success until he makes these applications clear to his students. We expect also in our agricultural colleges that the professors of botany, chemistry, entomology, physics, veterinary science, etc., will teach their branches with an inclination toward agriculture rather than toward developing scientists.

The agricultural department must be the leading department in the college, otherwise it will suffer by comparison. The sooner this idea is appreciated and this policy adopted by those in authority everywhere, the better it will be for our agri-

cultural colleges and the clearer will the professor of agriculture see his way to success.

One of the first things to do in building a house is to clear away the rubbish. As the average student comes to us from the farm there is liable to be some rubbish in his mind that needs removing. Possibly he holds too roseate a view of farm life, a sort of "bed of roses" theory, such as public speakers sometimes deal out to farmers, or, what is more likely in these times, the possibilities and real advantages of farm life is not fully appreciated. The "calamity howler" has got in his work; may be it has been dinned into the boy's ears from the cradle up. These extreme ideas should be cleared away and in their place the agricultural situation should be presented as it is; its advantages, its opportunities, its difficulties candidly weighed. Then go ahead on that basis and build up enthusiasm and love for the work by teaching the boys how to apply intelligence to labor, and see that they do it.

It always seemed to me that the logical place to begin in the teaching of agriculture was with the soil itself and from that point build up. Practically, however, we are unable to do this, in Michigan at least, for the reason mainly that our students are not sufficiently well grounded in scientific knowledge to take up this work to best advantage in their freshman year. Therefore we give, as our first instruction in agriculture, breeds of live stock. We study their history and characteristics. We illustrate so far as possible with living specimens and it is the policy and practice of our college to keep a large variety of specimens on hand. Where this is not possible a visit to neighboring herds would suffice. We have a complete set of herd books of all the pure-bred horses, cattle, sheep, and swine, and each student is required to trace the pedigree of one or more animals in each and to write an essay upon some one breed. Passing to the sophomore year we give instruction in soils, fertilizers, drainage, crops, how to cultivate them, advantages of leguminous plants in developing nitrogen in the soil, etc. We familiarize them with and instruct them in the various implements of the farm. In the junior year we give instruction in the breeding and feeding of live stock and the relation of the stock to the crops of the farm. This is necessarily quite scientific and yet our attempt is also to make it thoroughly practical. In the senior year specialties in farming are taught. All instruction is given by lectures, copies of which, containing reference notes, are distributed among the members of the class, thus avoiding the necessity of their taking notes.

Everything is illustrated so far as possible by seeing the actual thing itself and often by using it, or, if it is a piece of work, by doing it. Thus we teach the student some knowledge, and what is of equal importance, "how to know." One thing is left and that is, "how to do."

This brings us to the matter of student labor, one of the most difficult problems with which the professor of agriculture has had to contend. How can it be utilized to advantage? There are innumerable obstacles in the way. Well, the first thing to do is to cut entirely loose from the old idea that there is dignity in labor because it is labor or that labor is of any use whatever, except as a means to an end. It is valuable for what it brings. Most good things that come to us come through hard work. Indeed, this is true of all that we prize most highly. Labor for an object, good hard work, doing one's level best, is edifying; it strengthens character; it builds up manhood. Work for the sake of work soon becomes drudgery, is discouraging, and tears down rather than builds up. This is just as true of a student as of any one else. Possibly we have forgotten this. Take the student, then, on the assumption that he is somebody, that he is more than an average being, which he is, and treat him accordingly. If he is given a hoe and told to go out with Patrick to dig potatoes or stumps, placed on a level with unskilled labor, at half pay at that, is it any wonder that the boy does not like it? Is it any wonder that he kicks? He would not be much of a fellow if he did not kick. Students under the old system are troublesome and mischievous simply because they hate the system. A better

policy, and one that I am happy to say is now in successful operation at the Michigan college, is to take the student to one side and say to him: "We have a certain piece of work to do and we want you to do it. It will require both mental and manual labor. We can lay the plans and set Patrick to carrying them out, but we are morally certain that he will spoil something when our backs are turned. Now, you are a student, interested in this work, possessed of both intelligence and ability, and we want you to lay out the plans under our counsel and do the work, and we will hold you responsible for its success or failure." Suppose, by way of illustration, that it is an experiment with potatoes to determine the comparative value of different depths of planting, we say to him further: "This is to be your experiment; you are to read up all the bulletins and other literature that you can find upon the subject, post yourself thoroughly, prepare the ground, plant the potatoes, cultivate them, destroy the weeds, and keep off the bugs, and when through dig and weigh all the potatoes. Make full notes of your work and the condition of the crop from the beginning to the end of the experiment, and record the results in a book, which we will furnish for the purpose. This will be filed in our office and will serve not only as a memento of your labors, but if your work has been well done it will add one more item to the constantly accumulating fund of agricultural knowledge." What have we got now, a shirk, a drone, or a troublesome fellow? No. He is now interested, eager, enthusiastic, and instead of being a source of annoyance to us he has become our helper, our coworker, our pride. Each man can be furnished work according to his ability. That which is purely educational and of no benefit to the department is not paid for—that which is of benefit to the department is paid for. But all labor is thus educational. Now the student has not only learned "how to know," but he has learned "how to do." He has learned how to do one piece of work that required both thought and action and he has learned to do it well. This lesson is now a part of himself. It will abide with him forever. The experiment station has done double duty this time. It was one of the reasons why the stations were located at the colleges, that this might be done; that the student might learn (presumably it was thought that this might be accomplished by observation) something of experimentation. In the light of experience we are inclined to think that our benefactors builded more wisely than they knew.

To summarize: The professor of agriculture should teach, through his department, practical agriculture, or, in other words, should lay special stress upon the practical application of scientific truths concerning agriculture. He should divest the student's mind, through precept and example, of all false notions concerning agriculture. He must replace these with correct ideas, and at the same time lead him to become interested and enthusiastic in the work. Just what he teaches will depend considerably on where he is located. How he teaches it is of far more consequence. His great object should be to turn out successful agriculturists, who will go back upon the farms and make success in practical life. From those thus sent forth will come ample numbers of young men thoroughly competent, with a few additional years of post-graduate work, to fill positions in our agricultural colleges and experiment stations as teachers and investigators.

What a grand and noble work this is, the lifting up of the agricultural masses through the medium of our young men. It is a worthy ambition to be a professor of agriculture. The influence he exerts can not be measured. He has many difficulties, many trials, many discouragements, but all these vanish like mist before the sunlight of the great good he can do when his duty is properly performed.

METHODS OF IRRIGATION.

BY L. G. CARPENTER, *of Colorado.*

Irrigation may be practiced for two quite distinct objects: in one the water is valuable as an element necessary in plant growth, in the other as a manure for the substances it holds in suspension or solution. In the one case water is needed in com-

paratively small quantities, for the absolute needs of the plant are small; the application is discontinuous for short periods of time; other things being equal, the shorter, the better.

As a manure, water as it is found in nature is very dilute and when applied for this purpose it needs to be applied in large quantities. In cases it has been known to be so much that if the year's waterings were applied at once the plant would be submerged to a depth of over 200 feet by the water absorbed, or over 1,400 feet by that applied. Irrigation with large quantities is applied to meadows; it may be carried on in winter when the water is above the freezing point, and may be continued for days at a time, when if applied in small quantities injury would result to the character of the herbage.

The two cases I have mentioned differ in more than the quantity of water applied; there seems to be a different interaction between the sod and the water and its contents.

The limits of the two types are fixed somewhat by climatic considerations. When plants need watering there is usually a scarcity of that element, and irrigation with large quantities, as here meant, is not possible. Hence, as a general rule, dry and hot countries use less water than cold and wet ones. In the former all or most crops need irrigation; in the latter only forage crops are watered.

In practice there are insensible gradations, with variations too numerous to classify, leading from one type to the other.

In the United States we have been reluctant to practice irrigation except when compelled by necessity; our irrigation type consists in the use of small quantities of water, though the quantities may sometimes be considerable. These exceptions are few and isolated.

This type of irrigation we may divide into three methods, which may be subdivided indefinitely according to the plan of distribution adopted.

Before irrigation of either type can be practiced water must be brought to the land, which is done where possible by canals. Pumping is too costly except for low lifts or for exceptionally profitable crops. The irrigation canal differs from the navigation canal in that it seeks the high levels, so as to command as much land as possible. It may vary in width from 1 to 100 feet and in length from a few rods to 100 miles and over. It may water a few acres or hundreds of thousands. The greater canals cost hundreds of thousands of dollars for construction, frequently requiring long tunnels, expensive flumes, and large reservoirs. The expense may be borne directly by those interested or first by a company. The first cost is usually from \$5 to \$15 per acre.

From these principal canals secondaries are again built, which may be themselves of considerable size. These are usually constructed by separate corporations composed of those directly interested. These may again be divided, until finally the water is brought to the bounds of the undivided farm. It is only then that the farmer can complete his own system of ditches. The method he will adopt will depend upon various circumstances, the character of the soil and crop, the subsoil, the slope, the amount of water available, the amount of capital. Where mixed cultivation is practical it is essential that the method be applied to different crops, so that the same arrangement of ditches may be used for a series of years.

All methods are designed to accomplish the same object, which is to apply the water uniformly to the whole surface of the field, however irregular or uneven it may be. If more water is applied in one place than in another, unevenness in ripening or growth takes place; if it stagnates, then killing may take place, or in meadows, aquatic plants will appear. The minor inequalities are frequently leveled, but as yet extensive gradings are rarely attempted here, as is common for permanent meadows in Italy and France.

As before mentioned, irrigation in the United States is of the type with a limited amount of water. We may recognize three methods: (1) By submersion, (2) by flooding, (3) by infiltration, better known as the row or furrow system.

These may be again indefinitely subdivided according to the arrangements required for special classes of circumstances.

(1) *Submersion*.—In this case the farm is divided into compartments or basins by dikes of earth, 1 or 2 feet high. These are filled with water, which is allowed to stand until enough has been absorbed by the soil. Its convenience is that after once the ground is prepared it requires no skill in irrigation. The first cost is greater than with other methods. It is not well adapted to ground of a slope more than 20 feet to a mile, though sometimes used to 40 or even 60 feet. It is almost the only method which may be used for lands of less than 20 feet slope to the mile, hence its practice is largely confined to level countries. In Egypt it is successful with a slope of 6 inches to the mile. It has been practiced in Kern County, Cal., quite extensively. It requires large quantities of water so as to fill the compartments quickly, hence it is likely to go out of use on a large scale. The method is also used by the Mexicans. This method is used where water contains a valuable sediment and gives use to the system of *Colinatage*, as in the sterile plains in southern France.

(2) *Flooding*.—This method is that almost universally followed for cereals and meadows, and is the most elastic of methods, and capable of being infinitely varied in plan to suit the local needs. It may be used equally well with small or large supplies of water and with slopes from 20 feet per mile to the steepest. In this method the attempt is to cover the ground with an even sheet of flowing water. Temporary ditches, usually plow furrow, are needed to assist in the distribution. More skill is needed in the irrigator than in the other methods. The water is turned out from the laterals by small dams or cuts in the backs, and then the skill of the irrigator is required to distribute the water uniformly. By small dikes or a few sods the water is deflected to the higher places first; the low ones will take care of themselves. One important thing is never to allow the water to stagnate. This method is the general favorite. In some soils, as adobe, which are inclined to bake on drying, it has to be applied with caution, and sometimes the next method is used.

(3) *Infiltration*.—This is generally known as row irrigation, but there are some varieties which may be included in infiltration methods, and yet are not properly row irrigation. This method is that applied primarily to hoed crops which are planted in rows or need hilling, as corn, potatoes, beans, etc. The method consists in running the water between the rows, and for a time sufficient for the water to soak through the intervening space. It might be used for very steep grades, but precautions may then be necessary to prevent washing, as also in the case of flooding. The danger of this may be lessened in both cases by the direction the water is allowed to run along the slope. It is wasteful to make the rows long, though in one case when the rows were one-half mile long irrigation was given with a depth of 4 inches, which, as irrigations go, is economical. The question is almost invariably asked, "How much water is needed?" It may briefly be said: That it requires both favorable circumstances and skillful irrigation to make a uniform irrigation with depth less than 3 inches. The quantity varies according to crop, soil, and sub-soil. The amount applied in retentive soils by skillful irrigators in Colorado amounts with the rain during the irrigating season to from 27 to 32 inches. Experiments in New Mexico give about the same result, and considerable unpublished data from the southern end of the San Joaquin Valley, California, do not vary far from the same average.

Grass or forage crops will evidently take much more than grain crops.

In attempting to study our irrigation on any side one can not but be impressed with the little systematic knowledge we possess, and I can not forbear suggesting to our Western stations the importance of the problems connected with this practice which is the basis and the limit of the agriculture of the arid West. The whole field needs to be traversed; such experiments as those of Mangon, in France, thirty years ago, need to be repeated and extended. We need to know more of the methods, their limitations and capabilities, the amount of water needed, the sources of loss,

whether by plant-growth, transportation, evaporation from soil, or passage through subsoil. Our ultimate extent of agriculture in the extreme West depends on the economy we can make of water, and the ultimate economies will need to be pointed out by the experiment stations.

Another second remark I would like to make in regard to the East. There is a growing interest in the East, if one may judge from the correspondence that comes from there regarding the practice. I think the conclusion of every one who becomes acquainted with the practice in the West is that it would be profitable in the East wherever the conditions are favorable. Often the loss from drouth in a single year would more than pay all the expense of a system of irrigation, and there are few years when it would not increase the value of the products by several dollars per acre. The more I have become acquainted with irrigation the more have I become convinced of its desirability for the East, and the belief has become more settled, if possible, after studying this summer the irrigation of the valley of the Po, in northern Italy. This is too well known as the classic ground of irrigation in Europe to need description in that particular, and its fertility is proverbial. But coming from the West, where nothing grows without irrigation, and here seeing little difference between crops irrigated or not, the first question that struck me was, "Why do they irrigate?" The cereals are rarely irrigated, and all crops do well as a rule whether irrigated or not. The rainfall exceeds 30 inches, and is about the same as Michigan and central New York, and is as well distributed throughout the year. The important thing is, they do irrigate, and though they began it by degrees, six or eight centuries ago, they are so well satisfied with it that the area has doubled within the last thirty years, and they are willing to expend far larger sums in bringing water to the land than we in the West; as a rule, it is only the irrigated communities which are prosperous and which do not feel the presence of American and Indian competition.

The prosperity which comes with it is too well known to need remark. The influences of our experiment stations, which are interested in increasing the agricultural wealth and prosperity of the community, and improved methods, might find an additional line of usefulness in demonstrating by an object lesson at very small expense the applicability of irrigation to the East. The progress in the Eastern communities in this respect is apt to be slow, but, I think, it is known where the practice begun has been abandoned.

FORAGE PLANTS FOR THE SEMI-ARID WEST.

By C. C. GEORGESON, of *Kansas*.

By the semiarid West I mean in a general way the western half of Kansas and Nebraska and eastern Colorado. The boundaries are not sharply defined. There are years when the rainfall is sufficient to raise good crops of all kinds over the greater part of this area, and again on the other hand it frequently happens, as in 1860, 1874, 1881, 1887, and 1890, that the dry area is carried eastward almost to the Missouri River. This vast region, covering upwards of 100,000 square miles, presents some features which must always have an important bearing upon its agriculture. Thus the altitude increases steadily as we pass westward from the Missouri River. At Kansas City the elevation above sea level is only 763 feet; at Manhattan, 118 miles distant, it is 1,042 feet; at Ellis, 302 miles from the Missouri River, it is 2,135 feet; and at Monotony, a station but a few miles from the Colorado line, 3,741 feet. With rise in elevation there is a corresponding fall in the mean temperature. Spring is later by two or three weeks in the western part of Kansas than in the eastern part, and the fall frosts set in two or three weeks earlier. In like manner the rainfall decreases as we pass westward. At Leavenworth, Kans., the average annual rainfall is 38 inches; at Topeka, 68 miles from the Missouri River, it is 32 inches; at Salina, about 197 miles from the river, it is 29 inches; at Hays City it is 22 inches;

at Wa Keeney it is 19 inches; and at Fort Wallace, near the Colorado line, it is but 13 inches.

It will readily be seen that the agriculture of this region must differ in many essential points from the ordinary practice followed in the East. It is preëminently a stock country, and while it was settled only by nomadic stockmen who drove their herds in there for the summer season, the native buffalo grass answered all the demands for feed. But this condition no longer obtains. The once unbroken prairie is now dotted with improvements of permanent settlers, who must of necessity still make stock raising a prominent feature of their agriculture. In the valleys along the water courses, where irrigation is practicable, all farm crops succeed. But it is different on the uplands, where the settler must depend upon the meager rainfall. The small grains, wheat, rye, and in most seasons barley and oats do well there; but Indian corn, the great American forage crop, is a failure, or at least it fails so often that it is never safe to calculate on more than a crop of fodder. With them it is therefore a serious question what to grow in the line of forage plants. They must place their dependence on other crops than corn, but the question is, what shall it be? It is part of the duty of the Kansas Experiment Station to aid in solving this problem, and to this end we have experimented with a large number of forage plants. The station, however, is barely on the edge of this belt. It is located at 96° 40' west longitude, and the annual rainfall is about 30 inches. Manifestly many things would succeed with us which would be failures farther west, although we fail to grow satisfactorily most of the grasses so highly esteemed in the East. We can raise fine crops of red clover, and orchard grass is the surest of the tame grasses. But corn is frequently only a partial success. All of these fail in the semi-arid West. The United States Grass Station at Garden City, located in about 101° west longitude, has done some excellent work in testing forage plants suitable to that region. And I am indebted to Prof. J. A. Sewall, superintendent of the Station, for a list of the plants which he has grown successfully. He writes as follows:

"From the results of experiments of 1892, I can confidently speak of the following as profitable and practical: *Bromus inermis* (most excellent every way), *Panicum virgatum*, *Agropyrum glaucum* and *A. tenerum*, *Avena elatior*, *Festuca elatior*.

"Of the forage plants, the following have proved very successful: *Anthyllis vulneraria*, *Galega officinalis*, Alfalfa (*Medicago sativa*), Sainfoin (*Onobrychis sativa*), Red Kaffir corn, Jerusalem corn."

All of these, with one or two exceptions, have also been grown successfully at the Agricultural Experiment Station.

The sorghums, both saccharine and nonsaccharine, are grown with a measure of success in the West. The Early Amber and a few other sugar-bearing varieties are often sown broadcast and cut and cured for hay. It is a reasonably sure crop on the uplands, and furnishes a good article of feed. Of the nonsaccharine sorghums, the leading sorts are Red Kaffir corn, White Kaffir corn, Millo maize, Jerusalem Corn, and the so-called Egyptian Rice Corn, all of which are grown for the seed as well as for the fodder. We have tested upwards of one hundred and fifty varieties at the experiment station during the last three years, and the above named sorts take the lead. For the production of grain the Red Kaffir corn is the best of all. We have raised as much as 71 bushels seed per acre of this variety, and it matures early enough to escape injury from frost in ordinary seasons. The variety called Jerusalem corn was introduced only a few years ago, but has already gained favor with Western farmers. Prof. Sewall states that he has raised 30 bushels per acre with a rainfall of only 5.06 inches from sowing until harvest. The seed is not only good feed for cattle, but furnishes a fair article of human food.

Next to these, alfalfa is the most widely cultivated forage plant in the West. It grows to perfection on the lowlands, along streams, especially when irrigated, and it also does measurably well on the uplands, where it generally yields at least two cuttings, the second crop being frequently allowed to go to seed. While it can not

supply the place that clover occupies further east, it comes nearer to it than anything else so far brought into general culture. Many other forage plants have been tested, both at the United States Grass Station and at the Agricultural College Experiment Station, and among them are some of great promise. Of the grasses the one of greatest promise is *Bromus inermis*, a grass of comparatively recent introduction. It has done well at Manhattan during the last two years, and I concur with Prof. Sewall in pronouncing it "most excellent every way." It makes a close sod, and furnishes a thick growth of foliage of good quality, which is all that can be asked of any grass under those trying conditions. The other grasses mentioned by Prof. Sewall as eminently successful at Garden City have also been tried at Manhattan, where they did fairly well, but their growth has not been remarkable. And the same may be said of sainfoin, which Prof. Sewall recommends as excellent for sheep pasture at Garden City.

We have grown certain varieties of the Soy bean very successfully at Manhattan during the last three years, and it gives promise of becoming a very useful forage plant for the semi-arid region. It produces a highly nutritious feed, and it has the ability to withstand drought better than most farm crops. We grew this year a little over 6 acres of Soy beans, in four varieties. The season was dry and hot during July and August, yet they did not appear to suffer. A portion of each variety was made into ensilage, which is now being fed to the dairy cows. The silo was opened only the day before I left, and I am therefore unable to report results. The seed was distributed to many farmers over the State for trial the past season, and the following letter is a fair sample of the reports I received from the experimenters:

"WHITE CITY, KANS., *November 11, 1892.*

"DEAR SIR: Yours of the 29th at hand. In regard to the Soy beans received from you, would say that I planted them June 3. Owing to wet weather, the ground was plowed too wet, and consequently dried lumpy and hard. Jack rabbits ate about half of all the plants that came up. I raised, however, about a bushel and a half of beans from 2 pints of seed. They certainly are great drought-resisters. Dry weather don't seem to hurt them as it does other plants. I think them a boon to farmers in this western country, as a fodder and fertilizing crop.

"Yours truly,

JOHN HOLT."

I could produce many other similar reports, but this sample is sufficient. From the success thus far attained, I am encouraged to believe that the Soy bean is destined to play an important part in the agriculture of this semi-arid region.

The plants here mentioned comprise all that so far give promise to be of value for this region.

THE ESTABLISHMENT OF OFFICIAL METHODS OF EXPERIMENTATION.

By F. A. GULLEY, of *Arizona*.

In assigning this topic, I suppose it is the design of the committee to discuss the advisability of attempting the establishment of official methods of experimentation, something on the plan adopted by the Association of Official Chemists.

First, as to the possibility:

Official methods of chemical analysis are much easier to formulate than official methods of conducting the great variety of experiments undertaken by the stations.

The chemist deals with matter which may be separated, measured, placed under control, all that is added or eliminated known and estimated, and the final product definitely determined.

In an experiment which deals with animal or vegetable life we have a problem which includes many unknown quantities. We may keep a record of our opera-

tions, and we may measure what we supply in the way of nutriment, or perhaps it would be more accurate to say what we place in reach of the subject experimented with; but with all our skill we must confess that our actual knowledge of the subject at the start, of the effect of the treatment given, and of the final result, is so limited that our conclusion is pretty largely guesswork. As yet we can only judge superficially, owing to our lack of knowledge of principles. It would seem, therefore, that before we can attempt to formulate official methods of work, we must be prepared to do better work in many of the stations.

It was, perhaps, necessary in beginning, to do work, the result of which would satisfy the people in general that we were accomplishing something of value, work that had a practical application; but we are coming to the end of this class of investigations, and we have stumbled against a few rocks below the surface that must be grubbed out before we can go on.

It may be possible to adopt a uniform plan for conducting certain operations, but if the premises on which we base our work are uncertain or unknown, we can hardly hope for similarity in results.

Take for instance fertilizer and plant tests. Recent work in soil physics would seem to indicate that certain factors connected with the soil not yet understood may, under certain conditions, directly or indirectly influence plant growth to a greater extent than plant food as ordinarily supplied. Until we know something more of the mysteries of the soil, scientific manuring is a misnomer and results obtained misleading.

Our experiments have carried us but little farther than the general knowledge obtained by the practical farmer without our assistance, which may be expressed by saying that, generally speaking, land that is well fertilized and well cultivated will, as a rule, but not always, produce a good crop; and some soils and crops respond to certain kinds of fertilizers better than others, but not uniformly so.

In his report on Physical Properties of Soils to the Agricultural Department, of the present year, Prof. Whitney says the practical farmer can judge more correctly of the condition of the land and what it is best fitted to produce, from its general appearance, than the agricultural chemist can from a study of its chemical composition.

The agricultural chemists, or at least some of them, may not admit this to be the fact, but it may not be far from the truth.

The results we get from experiments in stock-feeding are as unsatisfactory as those in plant growing and fertilizer work.

We have obtained some general knowledge of the value of certain feedstuffs, but as in crop-growing the practical farmer is pretty close to us; while we have given him some valuable suggestions, and some of not much worth, when he questions us very closely we look wise and talk about compounding rations, nutritive values, and nutritive ratios, etc., something beyond his comprehension; and it is an open question if it is not somewhat hazy with us.

Books could be written on what we don't know of the influence of light, heat, and moisture, atmospheric influences on plant and animal growth; but enough in this line, except to say that this lack of knowledge of the principles that underlie our work seems to me the one great obstacle to the adoption of official methods.

I believe we all recognize the need, the absolute necessity in fact, for thorough and exhaustive study of those mysterious but active forces in soil, plant, and animal, not simply to enable us to work in the same way, but that we may work at all intelligently.

Where shall this work be done and who shall do it?

At one of the meetings of this Association, a large majority of the delegates present were utterly opposed to the establishment of a central station at Washington to be equipped for investigations of a higher order than could be provided for in the State stations, and I dare say the sentiment is as strongly against such a project

now as it was then. The work must be done, and several of the stations of the country are taking it up as far as their means will permit.

In looking over the Office of Experiment Stations Bulletin No. 12, I find the organization lists show there are fifty-three stations in forty-six States and Territories, six States having more than one station. Three hundred and twelve expert investigators are named in the list of station workers. This number includes but nine directors, while fully half of the station directors give part of their time to investigation; and it does not embrace assistants. The list is classified as follows:

11 Chemists,	49 Horticulturists,	46 Agriculturists,
38 Botanists,	35 Entomologists,	24 Veterinarians,
14 Meteorologists,	4 Biologists,	4 Dairymen,
4 Physicists,	3 Mycologists,	3 Irrigation Engineers,
2 Geologists,	1 Microscopist,	1 Viticulturist.

Twenty-seven men work in two lines, mostly doubling up on botany, horticulture, and entomology.

Of the regular stations, all but Ohio find it necessary to employ a chemist, while on the other hand the State stations of Massachusetts and Connecticut, with the exception of a mycologist in each, show only chemists on their lists.

The general plan of organization and work in one-half or three-fourths of the stations is very much the same, and with some slight difference in details, practically the same line of experiments have been taken up.

The question I would submit is this: Can 111 chemists, 49 horticulturists, 46 agriculturists, 38 botanists, 35 entomologists, etc., working in 46 different States and requiring as many different laboratories and sets of apparatus, working largely on the same lines, accomplish as much of value as could one-third of the number in each specialty, supplied with three times the facilities in the way of apparatus and assistants that they now have?

Official methods must be based on a better knowledge of principles than we now possess, but the study of principles requires expert skill and materials for working with, that are beyond the means of a station equipped for several lines of work.

We have progressed so far that further investigation in most lines requires for expert skill and apparatus an outlay of from \$4,000 to \$10,000 per annum for one line of work; and I can conceive of no establishment of official methods until many of our stations devote almost their entire energies to one line of investigation.

If the experiment station is to be considered a training school for college students or model farm for the people of the community, it should have the regulation outfit of agriculturist, horticulturist, chemist, botanist, entomologist, dairyman, etc., and a farm, garden, laboratories for each line of work—in fact, the whole field of agriculture should be represented. The head of each department should have his proportion of the funds to secure harmony, and such an institution would undoubtedly be of value in most States, but shall we expect much original research when the working force is spread over so much ground?

It would seem that the boards of control of some stations and some college presidents have not made sufficient distinction between the object of the agricultural college and the object of the agricultural experiment station, nor do they always appreciate the importance of costly ability and expensive machinery in the work of investigation.

While we have an immense area of country and great diversity of climate, there is not such wide variation in adjoining States that it is necessary to make the same investigations in each.

Disclaiming any intention of questioning the good judgment of State officials, I am of the opinion that we may add greatly to the value of our results by division of labor and expenditure of the greater part of the man power and funds of one

station in one line of work. Having made this change in our policy, it will be possible, I believe, to gradually establish official methods of experimentation.

I do not feel competent to present a plan for such division of labor, but I may be pardoned for submitting a few suggestions.

I would suggest a conference of station directors of groups of States lying near together and having somewhat similar conditions and interests; such as the New England States, the Central Mississippi Valley States, the northern, and southern halves of the arid belt, the Gulf States, etc.

In each one of these several groups of States there may be found as many important subjects for investigation as there are States, and these single lines of investigation, to a considerable extent at least, could be apportioned by mutual agreement, and the assignment made should constitute the special work of the station, to which should be given one-half, three-fourths, or better still, the entire energies of the station.

We have an example of what may be accomplished in equipping a station for a single line of work in the sugar station in this city.

Except in verification field tests, there is no necessity for attempting to duplicate the work of this station by expending \$1,000 or \$2,000 a year in any other Southern State.

Suppose some other station should take up the cotton plant as this station has sugar cane, is it not probable that we should get more positive data in regard to this plant from the one station than we now get from the nine or ten stations that have dabbled in cotton more or less?

Suppose some one station should confine its work to animal nutrition, or that two or three stations should divide the work between them, would it not be possible to disperse the fog that confuses our work in feeding?

The question of soil physics is of great importance in every State, but in the arid belt it is most important of all questions and most needs investigation. If, however, it is to be made one of ten lines of investigation carried on at the same time at one station with no additional help, it might better be omitted entirely.

But enough has been said on this line. I believe all will agree that a much higher class of work could be attempted and more knowledge gained by the division of labor suggested than is accomplished at present.

With the work of the experiment stations of the United States classified and apportioned as outlined, I believe it would be possible for this Association to appoint standing committees composed of men qualified to examine and make official reports upon the work of the stations adopting a specialty. The investigation of the methods of work could be made exhaustive, and from this careful scrutiny it would in time be feasible to build up a system of official methods.

WHAT IS THE LIVE WEIGHT OF AN ANIMAL?

By H. J. PATTERSON, of *Maryland*.

It is very evident to all who have had anything to do with the weighing of animals, or who have even given the matter thought in looking over the work of others, that there should be something more specific as to what should be considered the starting and ending weight of animals under experiment; how these weights should be obtained, and the manner, time, and condition in which animals should be weighed. The question of the great fluctuation in weight from day to day is worthy of considerable attention, and, if possible, steps should be taken to eliminate this source of error, or at least to greatly reduce it. In looking over the records of weights of animals under experiments and comparing the methods by which these weights have been obtained, we find that it is indeed a very confounding mass of figures, a set of figures which has mainly the effect of producing doubt and distrust. We find recorded in our station literature almost every conceivable method of obtain-

ing the weights of animals, having on the one extreme the holding of pigs at arm's length by their hind legs and guessing at the loss or gain, and at the other the weighing on delicate balances down to 1 gram. We also find that scarcely two persons will follow the same methods and details. It is often the case that the same person will not follow the same methods and details in two different experiments. Still worse, we sometimes find that there was no uniform method used as to manner, time, or condition of weighing the same animals throughout the same experiment.

It is only when we consider the fact of these great discrepancies and lack of uniformity, together with the fact that the conclusions of experiments are often based wholly upon the live weight, that the full importance of this subject becomes apparent.

The natural and normal state of animals is to have food and water always at hand and to partake of these whenever there is the slightest craving or inclination. In such surroundings, and other things being equal and normal, we should expect that the fluctuations in weight due to the change in the amount of material contained in the stomach should be reduced to a minimum. Unfortunately up to this time I have been unable to find any consecutive weighings of animals subjected to these normal conditions to test this point.

In the practice of feeding animals with the modern principles and advanced domestication many unnatural conditions have come into vogue, which makes it very important to us in our experiments to have some definite manner and condition for weighing, and to obviate, if possible, the extremes of fluctuation in weights due to the greater or less retention of food and water in the body.

The first question before us in this connection is: *Shall we weigh before or after feeding and watering?*

Reasoning on the basis that an animal's normal condition is to have all its wants satisfied, we should most naturally say that they should be weighed after feeding and watering. We also find that it is the common practice in stockyards to buy and sell cattle after they have had free access to hay and water. This custom has most probably grown out of the desire to eliminate sources of uncertainty and probable fraud.

To determine if the data at hand would throw any light upon this question I have collected and discussed the results of nearly 5,000 (4,988) weighings before and after watering. These figures have been procured from experiments with 34 different animals, varying from 15 to 175 consecutive weighings each. These represent all the figures I have had access to, which were at all comparable. Although many more like records exist it is believed that these are sufficient to answer our purpose.

The summary and averages of these weighings are given in the following table:

TABLE I.—Average of weighings.

Source of weights.	Date of beginning of experiment.	Animal.	Average weights.		Average amount of water drunk.	Number of weeks in experiment.	Fluctuation greatest before watering.	Fluctuation greatest after watering.	Average fluctuation.		Range of fluctuation.	
			Before water-ing.	After water-ing.					Before water-ing.	After water-ing.	Before water-ing.	After water-ing.
			<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>		<i>Wks.</i>	<i>Wks.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>
Md	Jan., '89	Cow Ramette.....	1,047	1,120	73	9	5	4	49	46	12—81	24—72
Md	Jan., '89	Cow Rose	767	814	47	9	3	6	31	34	18—70	13—78
Md	Jan., '91	Steer A	942	971	29	3	2	1	31	24	18—46	10—46
Md	Jan., '91	Steer B.....	956	985	29	4	3	1	28	30	18—38	16—42
Md	Jan., '91	Steer C.....	568	583	15	3	2	1	18	13	13—27	9—19
Md	Jan., '91	Steer D.....	571	590	19	4	1	3	21	20	17—25	12—25
Md	Feb., '92	Steer 1	730	744	14	3	0	3	22	35	14—28	31—41
Md	Feb., '92	Steer 2	741	768	27	3	1	2	23	35	21—24	23—57
N. Y....	Jan., '84	Cow Jem	700	739	39	9	3	6	26	31	6—37	15—45

TABLE I.—Average of weighings—Continued.

Source of weights.	Date of beginning of experiment.	Animal.	Average weights.		Average amount of water drunk.	Number of weeks in experiment.	Fluctuation greatest before watering.	Fluctuation greatest after watering.	Average fluctuation.		Range of fluctuation.	
			Before watering.	After watering.					Before watering.	After watering.	Before watering.	After watering.
			Lbs.	Lbs.	Lbs.		Wks.	Wks.	Lbs.	Lbs.	Lbs.	Lbs.
N. Y. . . .	Jan., '84	Cow Meg.	761	794	33	9	4	5	34	31	15—59	17—46
N. Y. . . .	Dec., '84	Cow Ceres.	740	806	66	23	4	19	32	45	10—65	13—86
N. Y. . . .	Dec., '84	Cow Juno.	903	954	51	23	8	15	40	47	7—79	10—83
N. Y. . . .	Dec., '87	Cow Jem.	902	965	63	8	2	6	34	39	15—75	18—69
N. Y. . . .	Dec., '87	Cow Meg.	882	950	68	8	1	7	18	30	7—26	15—53
Pa.	Dec., '85	Steer 1.	1,083	1,115	32	14	4	10	26	32	10—50	10—67
Pa.	Dec., '85	Steer 2.	1,051	1,079	28	14	3	11	21	24	8—40	10—52
Pa.	Dec., '85	Steer 3.	1,151	1,192	41	14	3	11	26	29	12—40	10—50
Pa.	Dec., '85	Steer 4.	1,125	1,176	51	14	6	8	19	18	5—40	5—50
Pa.	Dec., '85	Steer 5.	808	846	38	17	6	11	31	35	15—65	10—55
Pa.	Dec., '85	Steer 6.	699	728	29	15	7	8	25	26	5—40	13—40
Pa.	Dec., '85	Steer 7.	705	748	43	16	6	10	27	29	10—50	10—60
Pa.	Dec., '85	Steer 8.	643	677	34	17	7	10	29	29	15—60	15—50
Pa*	Nov., '86	Steer X.	1,083	1,103	20	2	1	1	11	11	0—27	0—38
Pa*	Nov., '86	Steer 1.	1,162	1,201	39	15	.....	.....	9.8	9.6	0—40	0—40
Pa*	Nov., '86	Steer 2.	1,156	1,205	49	15	.....	.....	7	7	0—30	0—35
Pa*	Nov., '86	Steer 3.	1,216	1,261	45	15	.....	.....	12	13	0—50	0—57
Pa*	Nov., '86	Steer 4.	1,174	1,211	37	13	.....	.....	7.7	9.2	0—37	0—50
Pa.	Nov., '87	Steer 1.	899	930	31	5	3	2	15	13	5—25	6—21
Pa.	Nov., '87	Steer 2.	976	1,011	35	5	2	3	21	26	12—35	13—45
Pa.	May, '88	Cow Topsy.	751	835	84	6	4	2	38	36	7—60	4—50
Pa.	Feb., '89	Steer 1.	944	966	22	6	3	3	31	33	18—50	25—43
Pa.	Feb., '89	Steer 2.	933	948	15	6	3	3	38	39	20—50	15—65
Pa.	Apr., '90	Cow Polly.	658	714	56	13	7	6	39	37	5—90	15—72
Pa.	Apr., '90	Cow Flossie.	605	662	57	23	11	12	35	37	7—85	5—190

NOTE.—The averages are made by taking the average of the weekly average, except in the cases marked (*), which are for the daily weighings.

From this table it appears: (1) That with 70 per cent of the animals the average fluctuation was greatest in the weights obtained after watering; (2) that with weekly weighings the range of fluctuation was greatest in the weights obtained after watering, with 60 per cent of the animals; (3) that the range of fluctuation in one week's weighings was from 0 to 190 pounds after watering and only from 0 to 90 pounds before watering; (4) that with the greatest care and following the methods least liable to error and having the minimum of fluctuation, we may have an error amounting to 10 or 15 per cent of the total weight of the animal used in experiments.

Let us next look at another phase of the question and see how the gains in weight, as obtained by weighing before and after watering, compare. For this purpose I have used the figures obtained with fourteen different animals under fattening experiments. The results are set forth in Table II.

TABLE II.—*Gains in fattening experiments as indicated by taking weights before and after watering, and using the averages of seven consecutive weighings at the beginning and ending of the experiments.*

Animals.	Number of weeks in experi- ment.	Gain before watering.	Gain after watering.	Differ- ence.
		<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Ramette	9	95	97	2
Rose	9	117	118	1
Steer 1 (1885)	14	126	134	8
Steer 2 (1885)	14	156	162	6
Steer 3 (1885)	14	120	140	20
Steer 4 (1885)	14	116	104	—12
Steer 5 (1885)	17	165	200	35
Steer 6 (1885)	15	130	150	20
Steer 7 (1885)	16	143	161	18
Steer 8 (1885)	17	155	170	15
Steer 1 (1886)	15	128	143	15
Steer 2 (1886)	15	153	153	0
Steer 3 (1886)	15	145	155	10
Steer 4 (1886)	13	138	131	—7

From this table it will be seen that in all but three cases the gains indicated by the weights taken after watering are greater than those obtained before watering and that in the extreme cases 17 per cent of the gain would appear to have been due to food and water. This gives particular stress to the importance of always weighing in the same conditions; and gains to be compared with each other should be obtained in the same manner.

What shall be considered the beginning and ending weight and how shall it be obtained?—It is already pretty well agreed that we should use the average of several consecutive weights for the beginning and ending weights of an experiment; yet we often note that there has been but a single weight taken at the beginning and ending of an experiment, and that they are used to represent the loss or gain due to the particular treatment. A glance at the great fluctuations as recorded in Table I is sufficient to tell that this is unreliable, and that we must use more than one weighing to obviate and reduce this source of error. There is a danger in the other extreme and there must be a limit; consequently how many weighings shall we make and use in our averages?

In Table III are recorded the average weights obtained by using three, five, and seven consecutive weighings with steers on maintenance and fattening rations; also the gains as indicated by following these different methods. From these results we find, as we would naturally expect, that with the maintenance ration it makes but little difference in the different averages whether we use three, five, or seven consecutive weighings, and that probably the more we use the more nearly we approximate the truth. With the fattening rations we find less difference in the different averages than we should expect—in fact, in most cases the agreement is surprising. On this basis alone we would not be warranted in advocating more than three consecutive weighings each at the beginning and ending of an experiment. Cattle on fattening rations and doing well should gain 2 or 3 pounds per day, from which we see that if we use the average of seven weights instead of three that we may introduce an error of from 10 to 20 pounds, and consequently record a gain which was really that much less than was truly the case. The results in a few instances as recorded in Table III indicate that this source of error has been introduced. From the fact as presented by Table III, and reasoning on the above basis, I doubt if we would be warranted in using more than three consecutive weighings for our averages to represent weights in fattening experiments.

TABLE III.

STEER 1.

	Before watering.				After watering.			
	First weight.	Average of three weights.	Average of five weights.	Average of seven weights.	First weight.	Average of three weights.	Average of five weights.	Average of seven weights.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Maintenance ration:								
Beginning	870	880	884	886	905	918	919	920
End of two weeks	897	892	898	901	930	930	929	933
Indicated gain	27	12	14	15	25	12	10	13
End of experiment	900	902	903	902	920	929	930	931
Total gain	30	22	19	16	15	11	11	11
Fattening ration:								
Beginning	1,130	1,116	1,112	1,116	1,145	1,136	1,141	1,148
First month	1,150	1,152	1,143	1,144	1,170	1,171	1,170	1,173
Gain	20	36	31	28	25	35	29	25
Second month	1,185	1,179	1,177	1,181	1,227	1,223	1,212	1,213
Gain	55	63	65	65	82	87	71	65
Third month	1,210	1,210	1,207	1,204	1,270	1,262	1,257	1,255
Gain	80	94	95	88	125	126	116	107
Fourth month	1,245	1,239	1,245	1,244	1,295	1,287	1,290	1,291
Gain	115	123	133	128	150	151	149	143

STEER 2.

	Before watering.				After watering.			
	First weight.	Average of three weights.	Average of five weights.	Average of seven weights.	First weight.	Average of three weights.	Average of five weights.	Average of seven weights.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Maintenance ration:								
Beginning	953	959	965	969	971	993	998	1,002
End of two weeks	980	978	980	984	1,005	1,011	1,012	1,014
Indicated gain	27	19	15	15	34	18	14	12
End of experiment	958	963	967	969	986	995	997	1,000
Total gain	5	4	2	0	15	2	-1	-2
Fattening ration:								
Beginning	1,087	1,102	1,103	1,105	1,145	1,141	1,145	1,148
First month	1,120	1,119	1,120	1,113	1,150	1,147	1,148	1,142
Gain	33	17	17	8	5	6	3	-6
Second month	1,187	1,170	1,171	1,170	1,225	1,215	1,208	1,207
Gain	100	68	68	65	80	74	63	59
Third month	1,245	1,238	1,235	1,231	1,290	1,290	1,280	1,278
Gain	158	136	132	126	145	149	135	130
Fourth month	1,255	1,253	1,256	1,258	1,300	1,297	1,298	1,301
Gain	168	151	153	153	155	156	153	153

TABLE III—Continued.

STEER 3.

	Before watering.				After watering.			
	First weight.	Average of three weights.	Average of five weights.	Average of seven weights.	First weight.	Average of three weights.	Average of five weights.	Average of seven weights.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Fattening ration:								
Beginning	1, 160	1, 167	1, 166	1, 169	1, 220	1, 209	1, 212	1, 214
First month	1, 205	1, 202	1, 194	1, 191	1, 225	1, 232	1, 225	1, 228
Gain.....	45	35	28	22	5	23	13	14
Second month	1, 234	1, 213	1, 222	1, 219	1, 285	1, 272	1, 262	1, 258
Gain.....	74	46	56	50	65	63	50	44
Third month	1, 300	1, 292	1, 291	1, 291	1, 300	1, 328	1, 334	1, 336
Gain.....	140	125	125	122	80	119	122	122
Fourth month	1, 315	1, 312	1, 314	1, 314	1, 372	1, 365	1, 367	1, 369
Gain.....	155	145	148	145	152	156	155	155

STEER 4.

	Before watering.				After watering.			
	First weight.	Average of three weights.	Average of five weights.	Average of seven weights.	First weight.	Average of three weights.	Average of five weights.	Average of seven weights.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Fattening ration:								
Beginning	1, 105	1, 107	1, 110	1, 115	1, 140	1, 143	1, 148	1, 155
First month	1, 132	1, 139	1, 142	1, 134	1, 167	1, 167	1, 170	1, 169
Gain.....	27	32	32	19	27	24	22	14
Second month	1, 195	1, 192	1, 192	1, 186	1, 235	1, 227	1, 228	1, 225
Gain.....	90	85	82	71	95	84	80	70
Third month	1, 250	1, 248	1, 246	1, 240	1, 300	1, 296	1, 293	1, 289
Gain.....	145	141	136	125	160	153	145	134
Fourth month	1, 240	1, 240	1, 247	1, 253	1, 260	1, 271	1, 276	1, 286
Gain.....	135	133	137	138	120	128	128	131

The question may come up in this connection as to whether there is any relation between the amounts of material consumed, matter voided, and the loss or gain in weight. In order to answer this question, Table IV has been added. But a glance at it is sufficient to show that there is no *direct* relation, for where the difference between food consumed and matter voided would indicate a gain of 34 pounds, we find one of only 4 pounds; and again where we have an indicated gain of 14 pounds, we find a loss in weight of 11 pounds, and so on throughout the list.

TABLE IV.—*Relation between food and water, excreta, and gain or loss in weight.*

Steer 1.						Steer 2.					
Fodder eaten.	Water drunk.	Total eaten.	Total voided.	Difference.	Loss or gain in weight.	Fodder eaten.	Water drunk.	Total eaten.	Total voided.	Difference.	Loss or gain in weight.
<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
11.7	32	43.7	33.4	+10.3	— 7	12.3	41	53.3	33.5	+19.8	— 7
11.0	10	21.0	23.1	— 2.1	—16	10.5	23	33.5	30.5	+ 3.0	— 5
11.3	36	47.3	28.0	+19.3	+ 6	9.7	35	44.7	31.7	+13.0	+ 3
11.7	44	55.7	21.4	+34.3	+ 4	10.0	38	48.0	28.6	+19.4	+ 2
11.0	33	44.0	29.4	+14.6	+ 3	13.5	25	38.5	24.7	+13.8	—10
11.5	30	41.5	29.5	+12.0	0	11.3	43	54.3	29.0	+25.3	+13
10.9	32	42.9	26.3	+16.6	+ 3	10.4	32	42.4	32.9	+ 9.5	+ 2
11.5	33	44.5	28.5	+16.0	0	11.0	20	31.0	25.7	+ 5.3	—20
11.5	33	44.5	32.9	+11.6	0	11.6	48	59.6	32.8	+26.8	+23
11.3	28	39.3	30.2	+ 9.1	— 5	11.7	28	39.7	25.6	+14.1	—11
12.1	33	45.1	29.3	+15.8	+ 2	11.3	18	29.3	27.7	+ 1.6	— 7
11.3	33	44.3	26.1	+18.2	+ 2	11.0	45	56.0	27.0	+29.0	+ 7
11.9	33	44.9	28.0	+16.9	0	11.3	28	39.3	24.9	+14.4	— 2
12.0	28	40.0	33.4	+ 6.6	— 2	11.2	30	41.2	31.4	+ 9.8	0
11.6	35	46.6	30.8	+15.8	0	10.9	35	45.9	26.1	+19.8	0
12.2	35	47.2	21.4	+15.8	0	10.8	40	50.8	29.2	+21.6	+ 2
11.6	30	41.6	31.1	+10.5	+ 5	10.6	29	39.6	25.6	+14.0	— 2
12.1	30	42.1	25.1	+ 7.0	0	10.7	25	35.7	27.6	+ 8.1	— 5
10.3	25	35.3	25.6	+ 9.7	— 3	11.0	30	41.0	30.1	+10.9	— 5
11.4	33	44.4	29.4	+15.0	+ 3	10.5	35	45.5	28.9	+16.6	0

SUMMARY.

From the figures and results which have already been presented the following conclusions may be warranted:

- (1.) That it would seem best to follow the rule of weighing before watering rather than after.
- (2.) That the average of three weighings at the beginning and the same at ending an experiment should be used as the starting and ending weights.
- (3.) We should always weigh in the same manner and condition.
- (4.) That it is evident we should endeavor to find methods by which to obviate the great fluctuations in weight which usually occur from day to day.

PHYSICAL TESTS OF SOILS.

By R. H. LOUGHRIDGE, of California.

The subject of soil investigation or inquiry into its chemical and physical nature has recently begun to assume some prominence among those scientists who give their time to the study of those conditions that promote or hinder the growth and development of plants and animals.

A few of these have, however, for many years believed the subject to be of prime importance and worthy of serious attention, as preliminary to investigations in which the relation of fertilizers to crops is concerned.

Among these, Dr. Robert Peter, of Kentucky, and Prof. E. W. Hilgard, formerly of Mississippi but now of California, are pioneers in this country; for they began the analyses and interpretation of results as long ago as the fifties.

As more than one thousand analyses of soils from some fifteen States have been made by them or under their supervision, and under conditions and methods so uniform as to make the results entirely comparable, I wish briefly to present these methods both chemical and physical, in order that by their adoption by the experiment stations, the comparability may be extended to all soils over the United States. That such a result is desirable in the extreme no one can deny; and its practical value has recently been very forcibly demonstrated in the comparison made by Prof. Hilgard of soils of the moist and arid regions of the Atlantic and Pacific slopes of the United States in his report to the Weather Bureau, entitled "Relations of soils to climate."

The method of actual analysis is perhaps in itself of no very special importance provided accurate results are obtained; for the results from a given solution should be the same by any method.

It is the method by which the soil solution is obtained that we wish to lay particular stress upon; the condition in which the analytical portion is taken; the solvent used and the time of digestion; for it is these that make the method presented by Prof. Kedzie the object of criticism.

Uniform methods in the preliminary treatment of the soil is then the main point to be insisted upon by those having at heart the comparability of results and the utilization and preservation of the immense amount of work already done.

In this preliminary work there are two points which mainly produce the great differences between the results by the one method and that by Kedzie.

The first is in the size of the meshes through which the soil is passed; or the limit in size of the particles which make up the so-called fine earth. The method of the Kedzie chemists places the maximum at 1 millimeter, while that of our method is one-half millimeter.

This admission of grains of from one-half to 1 millimeter into the calculation would produce in some soils a great difference in percentage results. In many of our sandy soils several per cent of such coarse materials would be added to the basis of calculation, and to that extent dilute the fine soil with inert matter. This question as to what should be rejected from the analyses was considered very early in the history of soil investigation, and both Drs. Peter and Hilgard concluded that all above one-half millimeter should be relegated to the rejected grit and gravel series, as comprising matters entirely devoid of plant food.

The percentages are determined, of course, but it is useless to clog the filter with this increased amount of insoluble residue and dilute the already small amount of plant food.

To include gravel and such coarse material in a chemical analysis is of course preposterous and a limit must be made to the size of the particles admitted to the fine earth. So long, then, as this limit is to be an arbitrary one, is it not by far the wisest course to adopt that of the one-half millimeter by which so much work has already been done than to take the one millimeter and throw out of comparison that work as well as the interpretation of results so carefully made by Prof. Hilgard on that basis. The hygroscopic moisture absorbed by a soil is a very important index to its power of resisting drouth, and hence is always determined under conditions representing the two extremes of extra dryness and of air saturated with moisture at a regular temperature.

We thus have data for comparison under uniform conditions; while on the other hand the Kedzie method takes an air-dried soil for its hygroscopic moisture determination, and the condition of atmosphere is not noted.

I have thus briefly sketched the points in the Kedzie method of analyses that are fatal to any attempt at comparison of results with the vast amount of work already done; and they are points embraced almost exclusively in the preliminary treatment of the soil. I will now present the method as used by us, and which has been prepared by Prof. Hilgard, and I sincerely hope that it will be adopted by those chemists who may take up the subject of soil analysis.

MECHANICAL ANALYSIS.

It is hardly necessary to review for you the troubles and trials that Prof. Hilgard was subjected to in his first investigation of the mechanical constituents of soil, and which led up finally to his designing the present apparatus, which he terms a soil elutriator.

I will only say that the cause of all his trouble in the use of the Nobel apparatus and with beakers was the strong tendency of the fine particles to coalescence, a ten-

dency that belongs to all from clay up to particles of 2 millimeters diameter or 16 millimeters hydraulic value. Prof. Hilgard therefore put into exercise his ingenuity and designed the present form of apparatus, though only recently has it been perfected as presented to you. A prime requisite is a uniformity in the velocity of each current of water.

To secure a uniform velocity it was of course necessary that the pressure of the column of water above the elutriator should be constant at whatever the height of water in the reservoir.

The Mariottes bottle fulfills these conditions, and is placed on a shelf some 15 or 20 inches above the top of the cylinder of the elutriator.

With this instrument very accurate results are obtained; and, what is more, sediment of any desired hydraulic value can be isolated by regulating the flow of the current.

The apparatus has the advantage over other methods, also, in permitting the operator to do other work, having only to keep an eye occasionally on it and an ear open to catch any irregular movement in churn or bubbles of air in the Mariottes bottle.

METHOD OF SOIL ANALYSIS.

[Adopted by Drs. Robert Peter and E. W. Hilgard in the analysis of over 1,000 soils of the Southern and Pacific States, for the Tenth United States Census, and for the various State reports by the same authors.]

The soil is thoroughly broken up dry with a rubber pestle, or, in case of clayey soils, digested with distilled water until thoroughly disintegrated. It is then sifted or washed (as the case may be) through a sieve of 5 millimeters clear aperture; if washed, the muddy water must be evaporated to dryness with the soil slush and the whole thoroughly mixed. The samples so obtained constitute the "fine earth" to be used in chemical analysis; the coarse portions are to be further segregated by sieves and their mineralogical constituents identified with the microscope, reagents, or Thoulet's solution, as the case may require. The fine earth is exposed to an atmosphere saturated with moisture for about twelve hours at the ordinary temperature (60°F.) of the cellar in which the box should be kept. For this it is sifted in a layer of about 1 millimeter thickness upon glazed paper, on a wooden table in a small covered box (12 by 9 by 8 inches) in which there is about an inch of water; the interior sides and cover of the box should be lined with blotting paper, which is kept saturated with water, to insure the saturation of the air.

After eight to twelve hours the earth is transferred as quickly as possible, in the cellar, to a weighed drying tube, and weighed; it is then placed in a paraffin bath; the temperature gradually raised to 200° (C.) and kept there twenty to thirty minutes (rapidity of raising temperature depending upon the amount of moisture in the soil), a current of dry air passing continually through the tube. It is then weighed again and the loss in weight gives the hygroscopic moisture in saturated air.

From the drying tube two quantities are weighed out; 2 to 2.5 grams for general analysis, and 3 to 3.5 grams for phosphoric acid determination. Of very sandy soils, as much as 4 grams may be taken for general analysis.

I.—GENERAL ANALYSIS.

(1) The weighed quantity, usually of 2 to 2.5 grams, is brought into a small porcelain beaker covered with a watch glass, treated with 8 to 10 times its bulk of hydrochloric acid of 1.115 specific gravity and two or three drops of nitric acid, and digested for five days over the laboratory steam bath. At the end of this time it is evaporated to dryness, first on the water bath and then on the sand bath. By this treatment all the silica is rendered insoluble.

It is now moistened with strong hydrochloric acid and two or three drops of nitric acid, warmed, and, after allowing it to stand a few hours on the water bath, treated

with distilled water; then it is filtered from the insoluble residue which is strongly ignited and weighed.

Note 1.—If the filtrate should be turbid the insoluble residue which has gone through the filter can be recovered in the iron-and-alumina determination.

The insoluble residue is next boiled for fifteen or twenty minutes in a concentrated solution of carbonate of soda, to which a few drops of caustic lye should then be added to prevent reprecipitation of the dissolved silica. The solution is then filtered hot.

The difference between the weight of the total residue and that of undissolved sand and mineral powder is recorded as "soluble silica," being the aggregate of that set free by the acid treatment, and that previously existing in the soil. The latter, however, rarely exceeds 5 per cent.

(2) The acid filtrate from the total insoluble residue is evaporated to a convenient bulk. In case the filtrate should indicate by its color, etc., the presence of any considerable amount of organic matter, it should be oxidized by aqua regia, otherwise there will be difficulty in separating alumina.

(3) The filtrate thus prepared is now brought to boiling and treated with ammonia, whereby the iron and alumina are precipitated; it is kept boiling until the excess of ammonia is driven off, and then filtered hot. (Filtrate A.)

Note 2.—If the boiling is continued too long, filtration becomes very difficult and a part of the precipitate may redissolve in washing. Filtration may be begun so soon as the nose fails to note the presence of free ammonia; test paper is too delicate. Failure to boil long enough involves the contamination of the iron-alumina precipitate with lime and manganese.

(4) The precipitation of iron and alumina is well washed with boiling water, then removed from the filter to a platinum dish. The small quantity which unavoidably remains on the filter is dissolved with hydrochloric acid (boiling); the filter is then added to the alumina or may serve for filtering the alumina subsequently.

The iron and alumina precipitate (with filter) of No. 3 is dissolved in a mixture of about 5 cubic centimeters hydrochloric acid and 20 cubic centimeters water. Then filter (see note 1) and make up to 150 cubic centimeters. Take 50 cubic centimeters for the determination of iron and alumina together (by precipitation with ammonia) and 50 cubic centimeters for iron alone; keep 50 cubic centimeters in reserve. Determine the iron by means of a standard solution of permanganate of potash, after reduction; this latter is done by evaporating the 50 cubic centimeters almost to dryness with strong sulphuric acid, adding water and transferring the solution to a flask, and then reducing by means of pure metallic zinc in the usual way. The alumina is then determined by difference.

(5) The filtrate A from iron and alumina is acidified slightly with HCl. and if too bulky, is evaporated down to about 25 cubic centimeters (unless the soil is a calcareous one) and the lime is precipitated from it by neutralizing with ammonia and adding ammonic oxalate.

The precipitation of the lime should be done while boiling, as the precipitate settles much more easily. It is allowed to stand for twelve hours, then filtered off, washed with cold water and dried. (Filtrate C.)

By ignition the precipitate is partially converted into the oxide. This is then heated with twice its bulk of powdered ammonium carbonate, moistened with hot water and exposed to a gentle heat (50 to 80° C.) until all the ammonia is expelled. It is then dried below red heat and weighed as lime carbonate. When the amount of lime is at all considerable, the treatment with ammonic carbonate must be repeated till a constant weight is obtained.

(6) The filtrate C from the lime is brought into a hard Bohemian flask, evaporated down over the sand bath and the ammoniacal salts destroyed with aqua regia (Lawrence Smith's method.) From the flask it is removed to a small beaker and evaporated to dryness. This process usually occupies four to five hours. The residue

should be crystalline-granular; if white-opaque, ammonic nitrate remains and must be destroyed by HCl.

The dry residue is now moistened with nitric acid and the silica present is separated by filtration from the filtrate which should not amount to more than 10 or 15 cubic centimeters. Sulphuric acid is then precipitated by treatment with a few drops of baric nitrate; both the solution and the reagent being heated to boiling. If the quantity of sulphuric acid is large, it may be filtered off after the lapse of four or five hours. (Filtrate D.) If very small let it stand twelve hours. The precipitate is washed out with boiling water, dried, ignited and weighed. (Filtrate D.)

Note 3.—Care should be taken in adding the barium nitrate to use only the least possible excess, because in such a small concentrated acid solution the excess of barium nitrate may crystallize, and will not readily dissolve in hot water. Care must also be taken not to leave in the beaker the large heavy crystals of baric sulphate, of which a few sometimes constitute the entire precipitate, rarely exceeding a few milligrams. Should the ignited precipitate show an alkaline reaction on moistening with water, it must be treated with a drop of HCl refiltered and reweighed.

(7) Filtrate D is now evaporated to dryness in a platinum dish; the residue is treated with twice its bulk of crystallized oxalic acid, moistened with water and exposed to gentle heat. It is then strongly ignited to change the oxalates to carbonates; this treatment with oxalic acid must be made in a vessel which can be kept well covered, otherwise there is danger of loss through spattering. As little water as possible should be used, as otherwise loss is difficult to avoid from evolution of carbonic gas. Spatters on the cover should not be washed back into the basin until after the excess of oxalic acid has been volatilized. The ignited mass should have a slightly blackish tinge, to prove the conversion of the nitrates into carbonates. White portions may be locally re-treated with oxalic acid. The ignited mass is treated with a small amount of water which dissolves the alkaline carbonates and leaves the carbonates of magnesia, proto-sesquioxide of manganese, and the excess of barium carbonate behind. The alkalies are separated by filtration into a small platinum dish (Filtrate E), and the residue well but economically washed with water on a small filter. When the filtrate exceeds 10 cubic centimeters, it will on evaporation show so much turbidity from dissolved earthy carbonates as to render refiltration on a minute filter necessary, since otherwise the soda percentage will be found too large, magnesia too small.

Note 4.—If on dissolving the ignited mass the solution should appear greenish, from the formation of alkaline manganates, add a few drops of alcohol to reduce the manganese to insoluble dioxide.

The residue of barium, magnesium, and manganese compounds is now treated on the filter with hydrochloric acid, and the platinum dish is washed with warm nitric acid (not hydrochloric, for the platinum dish may be attacked by chlorine from the manganese dioxide), dissolving any small traces of precipitate that may have been left behind.

(3) The solution containing the chlorides of magnesium and manganese is now freed from the barium salts by hot precipitation with sulphuric acid, and the barium sulphate, after settling a few hours is filtered off. The filtrate is neutralized with ammonia, any resulting small precipitate (of iron) is filtered off, and the manganese precipitated with ammonic sulphide. Let stand twelve hours, and filter (filtrate F); wash with cold water, dry, ignite, and weigh as manganic proto-sesquioxide Mn_3O_4 .

(9) The filtrate F from the manganese is now freed from sulphur by acidulating with hydrochloric acid, evaporating down if necessary, and filtering. From the filtrate the magnesia is precipitated by adding an equal amount of ammonia and treating with sodic phosphate. After standing at least twenty-four hours, the magnesia salts may be filtered off, washed out with ammoniacal water, dried, ignited, and weighed as magnesium pyro-phosphate.

(10) The filtrate E, which should not be more than 10 or 15 cubic centimeters, containing the carbonates of the alkalis, is evaporated to dryness and gently fused so as to render insoluble any magnesium carbonate that may have gone through; then redissolved and filtered into a small weighed platinum dish containing a few drops of hydrochloric acid, to change the carbonates into chlorides; evaporated to dryness, exposed to a gradually rising temperature (below red heat), by which the chlorides are thoroughly dried and freed from moisture so as to prevent the decrepitation that would otherwise occur on ignition. Then, holding the platinum basin firmly by forceps grasping the clear edge, pass it carefully over a very low Bunsen flame, so as to cause, successively, every portion of the scaly or powdery residue to collapse without fully fusing. There is thus no loss from volatilization, and no difficulty in obtaining an accurate, constant weight.

The weighed chlorides are now brought by means of a little water into a small beaker or porcelain dish, treated with a sufficient quantity of platinic chloride, and evaporated to dryness over the water bath. The dried residue is treated with a mixture of three parts alcohol and one part ether, leaving the potassio-platinic-chloride undissolved. This is put on a filter and washed with ether-alcohol. When dried the precipitate and filter are put into a small platinum crucible and exposed to a heat sufficiently intense to reduce the platinum chloride to metallic platinum and to volatilize the greater part of the potassium chloride. This is easily accomplished in a crucible which is roughened by being constantly used for the same purpose (and no other), the spongy metal causing a ready evolution of the gases.

The reduced platinum is now first washed with hot acidulated water, then with pure water, then all moisture is driven off and it is weighed. From the weight of the platinum is calculated the *potassic chloride* and the oxide corresponding; the difference between the weights of the total alkaline chlorides, and the potassic chloride gives the sodic chloride from which may be calculated the sodic oxide.

II.—PHOSPHORIC ACID DETERMINATION.

(11) The weighed quantity of 3 to 5 grams is ignited in a platinum crucible, care being taken to avoid all loss by dusting. The loss of weight after full ignition gives the amount of chemically combined water and volatile and combustible matter.

(12) The ignited soil is now removed to a porcelain or glass beaker, treated with four to five times its bulk of strong nitric acid, digested for two days, evaporated to dryness first over the water bath and then over the sand bath; moistened with nitric acid, heated and treated with water. After standing a few hours on the water bath it is filtered off from the insoluble residue and the filtrate is evaporated to a very small bulk (10 cubic centimeters) and treated with about twice its bulk of ammonium molybdate, thus precipitating the phosphoric acid. After standing at least twelve hours, at first on the steam bath, it is filtered off and washed with a solution of ammonium nitrate acidified with nitric acid. The washed precipitate is dissolved on the filter with dilute ammonia. After washing the filter carefully the ammoniacal solution is treated with magnesia mixture, by which the phosphoric acid is precipitated. After allowing it to stand twenty-four hours it is filtered off, washed in the usual way, dried, ignited and, weighed as magnesium pyrophosphate, from which the phosphoric acid is calculated. The per cent of phosphoric acid found is to be subtracted from that of the alumina.

Note.—When a gelatinous residue remains on the filter after dissolving the molybdo-phosphate with ammonia, it may consist either of silica not rendered fully insoluble in the first evaporation, or, more rarely, of alumina containing phosphate. It should be treated with strong nitric acid, and the filtrate with ammonic molybdate. Any precipitate formed is of course added to the main quantity before precipitating with magnesia solution.

HUMUS DETERMINATION IN SOILS.

About 10 grams of soil are weighed off into a prepared filter. The soil should be covered with a piece of paper (filter), so as to prevent it from packing when solvents are poured on it.

It is now treated with hydrochloric acid from 0.5 to 1 per cent strong (25½ cubic centimeters of strong acid and 30 cubic centimeters of water), to dissolve out the lime and magnesia, which prevent the humus from dissolving in ammonia. Treat with the acid until there is no reaction for lime; then wash out the acid with water to neutral reaction. Dissolve the humus with weak ammonia water, prepared by diluting common saturated ammonia water (173 cubic centimeters ammonia to .22 water). Evaporate the humus solution to dryness in a weighed platinum dish at 100, C.; weigh, then ignite. The loss of weight gives the weight of humus.

The residue from ignition is carbonated with carbonic gas, heated, and weighed, thus giving the ash. It is then moistened with nitric acid and evaporated to dryness. The residue is treated with nitric acid and water, allowed to stand a few hours, and the solution filtered from the insoluble residue, which is ignited and weighed, giving the silica.

The "soluble" phosphoric acid is determined from the solution by the usual method, as magnesian pyrophosphate. It usually amounts to a fraction varying from one-half to as little as one-tenth of the total in the soil.

While the P_2O_5 so determined is manifestly more soluble and more available to vegetation than the rest of that found by extraction with stronger acid, it is clearly not as available as that which, when introduced in the form of superphosphates, exerts such striking effects, even though forming a much smaller percentage of the whole soil. Nevertheless, very striking agreement with actual practice is often found in making this determination.

The estimation of "humus" by combustion in any form of the total organic matter in the soil gives results varying according to the season, and having no direct relation to the active humus of the soil.

It is strenuously suggested that in the presentation of the results of a soil analysis the order of the electrolytic series be observed, as in the schedule annexed, so as to facilitate comparisons. The "insoluble residue" is best placed at the head of the column, as it indicates at a glance, approximately, the general character of the soil, as sandy or clayey.

For suggestions concerning the interpretation of analyses made according to the above method see "Report on the Experiment Stations of the University of California," 1890, pp. 151-172.

SUGGESTED EXPERIMENTS IN BREEDING.

By WILLIAM H. BREWER, of *Connecticut*.

Practical breeding has become a greatly specialized art, and the natural laws involved are a very fit subject for experimental study at the stations. Although the general rules seem to be fairly well understood, nevertheless some of the fundamental laws of breeding are not yet established, and will not be until proved by experiments made for this special end by trained biologists working according to scientific methods.

For example: It is almost universally believed by practical breeders that "acquired characters" are sometimes, or at least to some degree, transmitted by heredity, and they practice accordingly. This belief has been so widely shared by scientists that until lately it has been a sort of scientific dogma.

Within a few years, however, this dogma has been questioned by a large number of very eminent biologists, many of whom deny it in toto and claim that from the very nature and basis of heredity such transmission can not take place under any circumstances nor to any degree whatever.

Between the two extremes there is a considerable following which allows the possibility of the heredity of "acquired characters," but denies that it has any practical value in the evolution of species in nature, and consequently plays no part in the improvement of breeds by art.

This uncertainty is so far-reaching in its applications and so important in its economic results that I suggest a few series of experiments to be made at agricultural experiment stations. The costly character of the best stock used in practical breeding and the cost of the means and appliances for breeding in its most advanced practice place this out of reach of the stations. The experiments I suggest may be carried out with some small and inexpensive species of domestic animals. The experiments had better be made with mammals than with poultry, and the laws involved can be as well established by experiments on rabbits, guinea pigs, or even rats and mice, as with the most expensive trotters or short-horns.

The eminent Prof. August Weismann and his followers claim that none of the changes produced on an animal after its birth are ever transmitted by heredity to its offspring, even in the slightest degree; that the changes in the parent due to nutrition, those which follow from increased or diminished function, the effects of mutilation, injury, and disease—in short, of "any of the external influences which act upon the body"—never are, and never can be, by any possibility, transmitted; that the fundamental causes of heredity absolutely forbid it.

I have yet to find the successful breeder who accepts this as an established law of nature, nor is it accepted by all biologists. I think, therefore, that experiment stations, established for the investigation of natural laws of economic importance, should undertake experiments to find out what is the law involved in such cases. I would suggest that the experiments be carried along in at least two parallel lines, one to determine the effect of nutrition, the other of function. These would be the easier and of more obvious application to the average practical breeder.

If rabbits, for example, are chosen for experiment, I would recommend that the beginning be made with a sufficiently large number of animals so that the breeding need not be very close, and that the original stock consist of several breeds, half a dozen or more, their blood to be variously mixed by crossing as the experiments go on in order that the mongrel produce may have a greater tendency to vary under the conditions imposed than if but one original breed was used whose characters were well fixed and more liable to breed true to the parent type.

Let two sets from the same stock be bred separately and the experiments carried on along two parallel lines; the one well fed during growth, that the mature animals may be of good and full size; the other be stunted during growth by under feeding. Consider this for a considerable number of successive generations, ten or fifteen at least, the one series continually well fed, the other continually under fed, and carefully record the results during the progress. Also keep a record of the number of each produced, that one phase of the mooted question of the causes of sex may be investigated at the same time.

Inasmuch as the whole increase of the flock could not be kept in the reducing of the numbers from time to time great care should be used that selection as to size be not practiced; they should be selected by averages, by weighing, or in some other satisfactory way.

The outcome of such a series of experiments would be of vast importance ultimately in determining the natural laws which underlie the best treatment for growing animals intended for breeding.

For determining the influence of the exercise or disuse of function another series is requisite. Function may be impaired by disuse, by injury, or by mutilation, by disease, or by other causes.

The most convenient and, for various reasons, the best way would be to impair function by mutilation. Suppose we use rabbits (as in the previously suggested experiments), beginning with a considerable number of breeds, and crossing until

one had a mongrel stock of the different breeds variously intermingled. Let us, from the beginning, amputate some one limb, soon after birth, of all the animals, always amputating the corresponding limb (say the left foreleg or the right hindleg, not the left of one animal and the right of another, but always the corresponding limb). Pursue this for at least ten or fifteen successive generations, and record the results. Some other injury might be more convenient, as the extirpation of an eye, inasmuch as there are several recorded cases of alleged transmissions of injury to the eye.

If mutilation be objected to, then resort to the more troublesome process of preventing use. Tie up or in some other way prevent the use of one limb or the use of one eye, from birth on, and note the effect, if any, on successive generations.

While such interference with function is not precisely the reverse of exercise and training (as shown in the development of speed in trotters and milk in cows), yet the laws involved are the same and would be of great scientific interest as well as of practical importance.

It seems to me that experiments on the removal of some organ of little use to the animal in domestication, such as cutting off the tail or an ear, would not fulfill the best condition for experiment. There is too little function involved.

A number of other lines of experiment readily suggest themselves; but I have long had this matter in mind, and on the whole, the directions I have indicated seem to me the most practicable, fair, and the most promising of results, and there can be no complete science of breeding until the fundamental laws are established.

While on this subject, I wish to suggest a line of observations to be recorded at those stations where cows are bred and where milk is tested. There is much assertion, but I know of no extensive recorded observations, as to the effect produced by the milking of the dam on the milking capacity of the offspring. Let a record be kept of the successive calves of each cow, to see if, on the average, the earlier calves are as good milkers as the later ones; if there is any difference, wherein does it lie? Observations on the offspring of any one cow are of little value; recorded observations on many would be of much value in establishing a rule.

RAMIE CULTURE IN THE SOUTH.

By C. R. DODGE, of Washington, D. C.

Will it pay Southern farmers to cultivate ramie? is a question easier to ask than to answer. At the very outset, we may reply emphatically "No," until a satisfactory machine decorticator or process has been presented that will produce the fiber at a cost allowing competition with the imported China ramie of commerce. But it is not my purpose to speak of the machine question at this time. For the sake of argument we will suppose that question settled, though it is not settled by any means.

Now, with a satisfactory machine or process, will ramie culture pay in those States bordering on the Gulf, where the plant is claimed to grow successfully? As far as my investigations have shown, and in spite of the experimental culture of ramie for many years in the South, it is simply impossible to answer the question, because these experiments have either been conducted in too superficial a manner with failure inevitable from the industrial standpoint, or they have been upon too small a scale to furnish a basis for reliable estimates. In making such a statement I am aware that figures have been published from time to time purporting to show the actual cost of growing an acre of ramie, but they have not borne the test of careful analysis.

Many claim that ramie culture will not pay. But the claim is also made in the South by others that a field of ramie will take care of itself after once planting, the soil requiring no special cultivation or manuring. Here is what a Southern writer says concerning the crop: "Ramie is preëminently a poor man's crop. It is the

easiest and least expensive in point of labor of all crops to produce." This is absurd. An experimenter said to me not long ago, "We have given up ramie; there is no money in it." But he did not tell me what I afterwards learned, that the roots had been set out in the poorest soil with no manuring, and had been practically allowed to take care of themselves. The owner of one of the largest tracts of ramie in Louisiana, speaking of his operations the present season, admitted to me after harvesting the crop that all his preconceived ideas upon the subject had been upset, and he was beginning to see where mistakes had been made.

The grain of wheat in all this peck of chaff is that before making any positive statements concerning the cost of ramie cultivation in the United States experiments must be conducted on a large scale for several seasons under most careful supervision, and the conditions of successful growth intelligently studied as they have never been studied in this country.

By successful growth I do not mean the ability of the plant to shoot up stalks of requisite height and to clothe these stalks with a healthy growth of leaves, but to ascertain if such stalks contain proper spinnable fiber after having been grown, and in sufficient quantity per acre to yield an adequate return for the expenses of cultivation and the subsequent expenses of extracting the fiber and degumming it for the spinner. A stalk of ramie either grows rapidly and rankly when there is an excess of moisture, or it is stunted and of slow growth when opposite conditions prevail.

Where one of these conditions follows the other in the same growing crop, the fiber is adversely affected, for, in the after processes to fit it for spinning, treatment necessary to reduce the hard or stunted growth to the condition of spinnable fiber may wholly disintegrate the structure of the fiber in the softer or free-grown portion of the stalk, and great wastage and loss ensue. Or, the stalks in one part of the field may produce one grade of fiber and those on another portion a different grade, or the crops from two cuttings may differ in the same way. An acre of ground should produce 10 to 15 tons of stalks with leaves; say $12\frac{1}{2}$ tons average, of 25 tons for two annual cuttings. French experiments have shown that every ton of stalks and leaves when properly treated will give about 25 pounds of the chemically degummed fiber fit for spinning. Records of these experiments show that this 25 pounds of fiber has cost for culture, cleaning, and degumming not over \$3. Multiply this by 25, the product of 25 tons of stalks with leaves, and we have a total of 625 pounds of spinnable fiber that have cost for cultivation and treatment, including chemical degumming, \$75. Yet only a few days ago I saw a published statement that the income to a Southern farmer for cultivation alone would amount to \$150 per acre.

Before the farmers of the South may be induced to go into ramie culture, several points should be settled that can not be settled by indifferently conducted experiments, or by cultivation on garden plot areas:

- (1) How many tons of stalks per acre can be regularly produced?
- (2) What quantity of spinnable fiber will an acre produce?
- (3) What methods of cultivation, drainage, irrigation with soil selection, or selection of location, will be necessary to produce an even quality of spinnable fiber one crop with another or in the same crop; and lastly, these questions having been satisfactorily answered, what profit will the balance sheet show between cost of cultivation and harvesting, and price that the spinner will pay for the degummed fiber? This, in short, means a connected study of the whole field of operations, culture, the machine problem or the cleaning of the fiber, and degumming, because the price of the commercial China grass, imported without duty, fixes the price of all fiber. The question may be asked, Why include the degumming, and why not stop with the machine-cleaned fiber, as the degumming is a part of the manufacturing process? I will reply that in the hand preparation of commercial ramie by the Chinese the product is partially degummed, and that the machine-prepared fiber in all prob-

ability will never bring the same price per pound as the Chinese for this reason. When the economically successful machine has been placed on the market, and careful field tests have shown the quality and quantity of the output we will know something more than is known now concerning the money value of machine-cleaned fiber, and it will not then be a difficult matter to say what the farmer's share of the ton value of the fiber will be.

Such connected study has been given to the industry in France, followed by valuable practical results, that have made it a recognized industry. The French figures of cultivation are available for our study and guidance, but they do not settle the various problems as regards cultivation in America where such different conditions prevail. We must therefore work out these problems for ourselves.

While these facts are in a sense discouraging, there are some most encouraging features. In the first place my recent investigations have shown that American experimenters degum the China ramie at almost half the cost at which it is degummed in France with a loss by waste of only 5 per cent against 30 to 40, as shown by the French records. If this saving can be made with China grass it can be made with the home grown product, which would mean more spinnable fiber to the ton of stalks, and at a less cost. One of the great expenses of harvesting the crop, the stripping of the leaves, will eventually be accomplished by the machine which strips the fiber, and France already has a machine that has shown promising results and which takes the stalks, leaves and all. And, finally, should a careful system of experiment demonstrate that we can produce good fiber at a paying cost, there is no doubt at all concerning the market. The absence of a regular supply of fiber, in the past, has been one of the chief obstacles that has hindered the manufacturing side of the industry, though there is now a better supply. Ramie goods are purchasable to-day in New York city, manufactured in France by a concern which runs over 5,000 spindles, and I know that capital on this side of the water is already interested in establishing manufacturing plants on a large scale. Their supply of the raw material must be derived from China, but Southern ramie will have equal chance when it has been demonstrated that we can produce good fiber at a cost that will enable its use economically.

The Government share in this work is to secure all available information, from every source, and disseminate this information through its publications, and by correspondence in answer to personal inquiry.

THE SECTION ON HORTICULTURE.

A meeting of the Section on Horticulture was called, but it appeared that only four members were present. An invitation having been received from the Section on Botany for the members of the Section on Horticulture to meet in joint section with them, it was thought best to accept it, and accordingly the two sections held their meetings in conjunction throughout the convention.

By a revision of the constitution the Sections on Horticulture and Botany were consolidated, hence the two sections will in the future meet together, forming a single section.

THE SECTION ON BOTANY.

The Section on Botany organized at 7:30 p. m. November 15.

In the absence of the chairman Prof. P. H. Mell, of Alabama, was elected chairman *pro tem*.

The horticulturists were invited to meet with the Botanical Section. The following persons were present at the different sectional meetings: Halsted of New Jersey, Earle, Tracy, and McKay of Mississippi, Mell and Duggar of Alabama, True of Washington, D. C., Goff of Wisconsin, Woods of Connecticut, Speth of Georgia, Munson of Maine, Scribner of Tennessee, McCluer of Illinois, Neal of Oklahoma, Gulley of Arizona, Osborn and Pammel of Iowa, Warder of Ohio, and F. H. Burnette of Louisiana.

A committee of three, consisting of Messrs. Scribner, Goff, and Pammel, was appointed to consider the papers in hand. The following papers were referred for reading at the general session:

Notes on the treatment of apple scab, by E. S. Goff; Results of spraying potatoes for prevention of blight, by L. R. Jones; Fruit rots, a study, by B. D. Halsted; Notes on the breeding of fruits, by N. E. Hansen; Crossing of cucurbits, by L. H. Pammel.

On November 16, at 10:30 a. m., the section was favored with a talk on the laboratory exhibit of botany and horticulture at the Columbian Exposition by Mr. True, and on the work for the botanical alcove by Mr. Tracy.

On November 17, at 7 p. m., Mr. Halsted acted as chairman and the following papers were presented before the section:

Bean anthracnose and its treatment, by S. A. Beach.—Various fungicides like Bordeaux mixture and cupric borate were experimented with. It was also shown that plants from healthy seed were better than those of diseased seed. At the time of first picking they were ahead by thirty-eight points on yield by pods, forty points on yield by weight, and seventy-five points on condition of foliage; but for the entire season the difference was but nine points, seventeen points, and eight points respectively.

Some experiments in the prevention of Cercospora ribis and Cyindrosporium padi, by L. H. Pammel.—Attention was called to the successful application of Bordeaux mixture, half strength during the season of 1892.

Ammoniacal carbonate of copper half strength and sulphosteatite, as a powder, failed to be as valuable as Bordeaux mixture for the treatment of currants. Those treated with the latter mixture retained their foliage well in October. *Cylindrosporium padi* on cherries can easily be prevented by the use of Bordeaux mixture. Mr. Goff also found Bordeaux mixture valuable for currants.

Quince disease, by B. D. Halsted.—The following fungous troubles of the quince fruit were treated, namely: the quince rust (*Ræstelia aurantiaca* Pk.); fruit spot (*Entomosporium maculatum* Lev.); black rot of the quince (*Sphaeropsis malorum* Pk.); quince pale rot (*Phoma cydoniae* Sacc. ?); ripe rot of the quince (*Glæosporium fructigenum* Berk.), and the quince blotch, due to an unrecorded fungus, the life history of which is still obscure. The black rot is the same as that of the apple, and the fact that a large apple tree had the ground beneath it covered with rotting apples, doubtless had much to do with the prevalence of the rot in the quinces. The pale rot may not be *Phoma cydoniae* Sacc., the description being so meager as to leave a doubt. The ripe rot is the same as that of the apple, as proved by inoculation.

Antagonistic relations of certain potato rots, by L. R. Jones.—He called attention to the great abundance of *Phytophthora infestans* in 1890, 1891, and 1892. There are three common blights in Vermont. *Phytophthora infestans* does its greatest damage on medium and late potatoes. The "new disease" destroyed the potato vines by the first week in August before the conditions of weather were such as to favor the development of *Phytophthora*.

Preliminary notes on rutabaga and turnip rot, by L. H. Pammel.—A disease doing considerable damage, in some cases destroying half the crop, occurred on the Iowa Agricultural College Farm. Dry weather in September almost checked the progress of the disease. The disease is due to a bacterium. Several germs were isolated and one apparently produced the disease in the field. But this is not conclusive evidence that it is the specific germ, as the experiments carried out do not conform to all of the Koch canons.

A new "damping off" fungus, by George F. Atkinson.—A sterile mycelium of a fungus which causes "damping off" of cotton, *Dolichos sinensis*, cauliflower, alfalfa, etc., was isolated. The fungus was grown in nutrient media and young plants inoculated producing the characteristic "damping off." From these plants the fungus was again obtained. The fungus is probably a member of the *Hymenomycetes* or *Discomycetes*.

Relation of frost to certain plants, by L. H. Pammel.—In this paper the exact temperatures at which various plants were affected by frost were noted. In some cases parts of a plant close to the ground were affected while the upper were not injured as in castor-oil bean (*Ricinus communis*). On October 18 the minimum temperature close to the ground was 18° F. Five feet from the ground it was 36° F.

New Jersey mildews (Peronosporæ), by B. D. Halsted.—The chief point in the record for the year is, that while the latter portion of the growing season has been unusually dry, there has been more than the ordinary amount of those members of the group belonging to the genus *Cystopus*. In a further study of the methods these disastrous mildews have for passing the winter, it was found that some species grow upon the fruits and that doubtless the filaments of the fungus penetrate the seeds and when the latter germinate the parasite develops with the host. Large numbers of small young seedlings were taken that were badly infested.

The importance of making field notes upon the prevalence of parasitic fungi extending over many seasons was urged.

Weed seeds, by B. D. Halsted.—Samples of a collection of weed seeds were shown. The set consists of one hundred species of our worst weeds, and the seeds are put up in dram, metal screw-top, vials arranged in a tray, about the size of a herbarium sheet. Each bottle has a printed label, bearing a number and the botanical name of the seeds contained. To the inside of the tray cover is pasted a corresponding list with common names added, and whether the species is native or foreign, and whether annual, biennial, or perennial. The set is designed to assist experiment station workers in determining the nature of foul stuff in commercial seeds. It will also serve the same purpose for the wholesale dealers in seeds.

Method of obtaining pure cultures of Pammel's fungus of Texas root-rot of cotton, by Geo. F. Atkinson.—It is difficult to grow many fungi in nutrient media, and this is one of them. Several attempts were made to induce this fungus to part with its host. When grown in sand in moist chambers the strands grew several inches long, but they failed to grow in nutrient media when transferred. Baits were provided and after some difficulty the fungus was obtained in a pure state.

The section nominated Mr. F. Lamson-Scribner, of Knoxville, Tenn., for chairman, and Mr. E. S. Goff, of Madison, Wis., secretary.

The section then adjourned.

GEO. F. ATKINSON,
Chairman, Ithaca, N. Y.
L. H. PAMMEL,
Secretary, Ames, Iowa.

INDEX.

NAME LIST.

- Aldrich, J. M., 50.
Allen, E. W., 15.
Alvord, H. E., 11, 12, 15, 16, 21, 23, 24, 28, 58, 66,
71, 72, 73, 75, 77, 78, 79, 80, 84, 87, 97, 98, 103, 104,
106, 107, 108, 109, 110, 113, 116, 119, 122, 124, 126.
Alwood, W. B., 35, 50.
Anderson, D. S., 14.
Anderson, F. P., 12, 110.
Armsby, H. P., 15, 18, 22, 74, 98, 99, 102, 107, 111, 124.
Arthur, J. C., 34.
Atherton, G. W., 15, 21, 22, 24, 74, 80, 85, 103, 111,
112, 117, 120, 122, 124, 125.
Atkinson, G. F., 11, 17, 18, 19, 33, 34, 35, 42, 169, 170.
Ayres, B., 14.
Babcock, S. M., 111.
Barrow, D. N., 14.
Battle H. B., 18, 40.
Beach, S. A., 34, 168.
Beaver, J. A., 85.
Beckwith, M. H., 43.
Bessey, C. E., 34.
Black, S. E., 15.
Blouin, R. E., 14.
Bolley, H. L., 19, 34.
Bondurant, A. J., 13.
Brewer, W. H., 18, 130, 162.
Broun, W. L., 11, 13, 17, 19, 21, 58, 79, 120.
Bruner, L., 11, 12, 18, 41, 51.
Brunk, T. L., 11.
Buchanan, J. B., 15, 79.
Buchanan, W. I., 22, 99, 100, 108.
Buckhout, W. A., 34.
Budd, J. L., 73.
Burnette, F. H., 14, 168.
Burrill, T. J., 34.
Burrus, J. D., 14.
Burwell, R. T., 14.
Butler, T., 14.
Butterfield, I. H., 14.
Cameron, John, 85.
Carpenter, L. G., 13, 18, 130, 142.
Cavitt, W. R., 15, 79, 85, 126.
Chamberlain, H., 14, 21, 85.
Chester, F. D., 33.
Clute, O., 14, 56, 86, 118.
Coleman, J. W., 15.
Collingwood, C. B., 38.
Comstock, J. H., 49.
Cook, A. J., 47.
Cooke, W. W., 15, 18, 101, 129.
Cooper, W. J., 14.
Craig, M., 34.
Crawley, J. T., 14.
Cross, J. L., 14.
Curtis, G. W., 15, 18, 67, 71, 129.
Dabney, C. W., jr., 11, 12, 15, 40, 75, 78, 79, 102, 103,
106, 109, 110.
Dale, H. B., 15, 85.
Davidson, R. J., 41.
Deiler, J. H., 14.
De Pass, J. P., 13, 76, 78, 110, 117.
Detmers, F., 34.
Dillard, J. H., 14.
Dixon, B. V. B., 14.
Dodge, C. R., 130, 164.
Doran, E. W., 46.
Dougherty, N. S., 15.
Dudley, W. R., 33.
Duggar, B. M., 13, 168.
Earle, F. S., 14, 168.
Emery, F. E., 11.
Fairchild, D. G., 34.
Fairchild, G. T., 13, 27, 52, 53, 67, 86, 110, 113, 116,
117, 122.
Farrington, E. H., 38.
Fernald, C. H., 46.
Fernald, M. C., 12, 14, 53, 70, 73, 110, 121.
Ficklen, J. B., 14.
Fitzpatrick, J., 19, 21.
Flagg, C. O., 15.
Fletcher, J., 51.
Forbes, S. A., 44.
Fortier, A., 14.
Foster, L., 18.
Foster, M. J., 19, 21.
Frear, W., 11, 15, 73, 112.
Gardner, F. D., 18.
Garman, H., 34, 45.
Georgeson, C. C., 13, 18, 67, 129, 145.
Gibson, H., 85.
Gill, C. T., 14.
Gillette, C. P., 43.
Goessman, C. A., 39.
Goff, E. S., 12, 15, 35, 51, 87, 110, 168, 169, 170.
Goodell, H. H., 11, 12, 14, 24, 103, 109, 111, 120, 125.
Goss, A., 40.
Grange, E. A. A., 101.
Gulley, F. A., 13, 18, 67, 80, 85, 111, 129, 147, 168.
Hadley, H., 14, 24, 72, 73, 74, 76, 78, 86, 103, 113, 121,
122.

- Hall, C. W., 12, 14, 57, 110, 137.
 Hall, T. T., 14.
 Halsted, B. D., 14, 18, 19, 34, 91, 168, 169, 170.
 Hansen, N. E., 92, 167.
 Hardin, M. B., 40.
 Harrington, H. H., 11, 40, 106.
 Harris, A. W., 15, 17, 80, 81, 84, 85, 87, 98, 99, 106, 125.
 Harvey, F. L., 34, 46.
 Harwood, P. M., 14, 18, 52, 67, 71, 129, 139.
 Hays, W. M., 15, 18, 52, 108, 110, 129, 130, 132.
 Henry, J. M., 14.
 Henry, W. A., 11, 12, 15, 17, 18, 53, 57, 67, 80, 85, 87, 102, 109, 110, 111, 129.
 Hickman, J. F., 11, 15, 18, 109.
 Hilgard, E. W., 11, 18, 67, 106, 109, 135, 156, 158.
 Hill, H. A., 14.
 Hillman, F. H., 48.
 Hills, J. L., 41.
 Hitchcock, A. S., 33, 34.
 Holcombe, J. W., 15, 18, 113, 118, 119, 122, 123.
 Holladay, A. Q., 11, 15, 109.
 Holt, John, 147.
 Holter, G. L., 40.
 Hopkins, A. D., 51.
 Huggins, J., 13.
 Humphrey, J. E., 33, 34.
 Hunnicutt, J. B., 13, 73.
 Hunt, T. F., 11, 15, 18, 24, 76, 110, 113, 119, 120.
 Hurt, A. D., 14.
 Huston, H. A., 13, 39.
 Hutchinson, T. P., 14.
 Hutchinson, W. L., 39.
 Ingersoll, C. L., 11, 14, 18, 28, 33, 52, 67, 129, 138.
 Jamieson, H., 14.
 Jenkins, E. H., 38.
 Johnson, A. A., 15, 82, 87.
 Johnson, S. W., 12, 13, 71, 83, 86, 87, 109.
 Johnston, W. P., 14, 19, 21.
 Jones, L. R., 35, 88, 168, 169.
 Jordan, W. H., 11, 18.
 Keffer, C. A., 47.
 Kellerman, W. A., 33.
 Kilgore, B. W., 15.
 King, F. H., 15, 18.
 Kinney, L. F., 35.
 Latta, W. C., 12, 110, 129.
 Lee, J. G., 14.
 Lee, S. D., 14, 27, 52, 54, 55, 56, 98, 103, 108, 109, 110.
 Lloyd, E. R., 14.
 Loughridge, R. H., 13, 103, 129, 156.
 Lugger, O., 47.
 Lupton, N. T., 13.
 McCarthy, G., 19, 34.
 McCluer, G. W., 13, 168.
 McGee, W. L., 14.
 McKay, A. B., 14, 168.
 McLaren, D., 18.
 McNeill, J. F., 43.
 Mell, P. H., 13, 33, 168.
 Merry, J. F., 15, 106, 125.
 Miller, R. H., 14, 126.
 Morgan, H. A., 13, 45.
 Morrill, J. S., 108.
 Morrow, G. E., 13, 18, 22, 67, 102, 103, 104, 105, 106, 124, 125, 129.
 Morse, F. W., 39.
 Munson, W. M., 14, 168.
 Murfee, E. H., 13.
 Murray, W., 15.
 Myers, J. A., 11, 15, 79, 80, 85, 109, 111.
 Needham, D., 85.
 Newman, J. S., 15, 18, 24.
 Neal, J. C., 15, 120, 168.
 Neale, A. T., 11, 13, 80, 85, 111.
 Neilson, James, 12, 14, 76, 78, 82, 103, 109.
 Nicholson, J. W., 11, 13, 97.
 Nickerson, W. J., 14, 73.
 Niswander, F. J., 51.
 Northrop, C., 126.
 O'Brine, D., 38.
 Orcutt, I. H., 50.
 Ordway, J. M., 14.
 Orr, H. B., 14.
 Osborn, H., 13, 41, 44, 110, 125, 168.
 Palmer, B. M., 21.
 Pammel, L. H., 11, 13, 19, 34, 92, 94, 125, 168, 169, 170.
 Paquin, P., 101.
 Patrick, G. E., 39.
 Patterson, H. J., 14, 18, 39, 120, 150.
 Patterson, J. K., 13, 74.
 Pearce, J. W., 14.
 Pendergast, W. W., 137.
 Perkins, G. H., 50.
 Peter, Robt., 156, 158.
 Phelps, C. S., 18.
 Plumb, C. S., 13, 52.
 Popenoe, E. A., 11, 45, 52.
 Porter, E. D., 14, 116, 117, 118.
 Price, R. H., 35.
 Quick, W. J., 13, 110, 129.
 Redding, R. J., 13, 81, 85, 87.
 Richman, E. S., 50.
 Riley, C. V., 42, 43.
 Roberts, I. P., 15, 18, 87, 103, 108, 109, 111, 118, 129.
 Rogers, W. O., 14.
 Rolfs, P. H., 33, 44.
 Ross, B. B., 13.
 Roussell, J. N., 14.
 Roy, V. L., 14.
 Rynerson, W. L., 14, 79, 85.
 Sanborn, J. W., 15, 18, 27, 52, 53, 55, 99, 109, 110.
 Scott, Austin, 14, 75, 78, 85, 103, 115, 116, 117, 120, 125.
 Scovell, M. A., 11, 12, 13, 21, 22, 24, 35, 41, 73, 78, 101, 109, 111, 129.
 Scribner, F. L., 12, 15, 35, 110, 168, 170.
 Sharp, R., 14.
 Shaw, G. W., 40.
 Slosson, E. E., 41.
 Smart, J. H., 13, 22, 24, 55, 78, 97, 103, 111, 112, 121, 122, 125.
 Smith, C. D., 18.
 Smith, J. B., 48.
 Smyth, E. A., jr., 35.
 Snow, F. H., 45.
 Snyder, H., 39.
 Soniat, Lucien, 14.
 Speth, G., 13, 168.
 Stockbridge, H. E., 11, 126.
 Stubbs, W. C., 11, 14, 21, 24, 109, 110, 124, 125, 129.

- Sturgis, W. C., 33.
 Silvester, R. W., 126.
 Teller, G. L., 38.
 Thorne, C. E., 15, 18, 101, 102, 103, 129, 130.
 Toumey, J. W., 33, 42.
 Townsend, C. H. T., 49.
 Tracy, S. M., 14, 18, 33, 34, 88, 102, 110, 168.
 Troop, J., 44.
 True, A. C., 15, 168.
 Turner, E. M., 11, 15, 18, 24, 27, 52, 67, 71, 73, 77, 108, 120.
 Vanderford, C. F., 15, 129.
 Vasey, G., 18.
 Von Phul, W., 14.
 Voorhees, E. B., 18.
 Waldron, C. B., 49.
 Walker, F. A., 126.
 Warder, R. H., 15, 85, 163.
 Washburn, F. L., 49.
 Washburn, J. H., 15, 121.
 Waters, H. J., 18.
 Webster, F. M., 11, 12, 49.
 Weed, C. M., 48.
 Weed, H. E., 14, 47, 48.
 Wheeler, C. F., 33, 34.
 Wheeler, H. J., 40.
 Whitcher, G. H., 14.
 Whitney, M., 18, 106.
 Willits, E., 98, 99, 106.
 Wilson, J., 18.
 Wilson, N. E., 14.
 Wiley, H. W., 15, 103, 125.
 Williams, T. A., 35.
 Williams, W. L., 101.
 Wing, H. H., 15, 18, 67, 101, 103.
 Woll, F. W., 15.
 Woods, C. D., 13, 38, 73, 77, 163.
 Woodward, W., 14.
 Woodworth, C. W., 43.
 Wooten, E. O., 34.

SUBJECT LIST.

	Page.
Advances in agricultural education.....	132
Advisory board to committees on college and station exhibits at World's Columbian Exposition.	79, 85
Agricultural Congress at World's Columbian Exposition, report of committee.....	104
education, advances in.....	132
experiment stations, list of directors.....	3
science, resolution indorsing.....	125
Agriculture and chemistry, minutes of section.....	129
officers of section.....	110
programme of section.....	18, 67
report of section.....	28
U. S. Department of, resolution of coöperation.....	112
what shall professors of, teach.....	139
Analysis of soils, methods.....	158
Annual address of president.....	58
dues of institutions.....	108
Apple scab, treatment.....	87
Association of American Agricultural Colleges and Experiment Stations—	
call for convention.....	16
change of title.....	76, 78
constitution.....	7
revision of.....	71
election of officers.....	109
local programme.....	19
number and length of sessions.....	109
officers.....	11
programmes of meetings.....	17
report of executive committee.....	21
report of treasurer.....	24
Auditing committee, appointment.....	24
report.....	113
Bibliographer, duties.....	77
Botany, minutes of section.....	168
Botany, programme of section.....	18
report of section.....	33
Breeding of fruits.....	92
suggested experiments in.....	162
Bureau of Education, form of schedule required by.....	116
relation of colleges to.....	114
editing and publishing reports of presidents of colleges by.....	113
resolution on work of.....	124
Bust of Hon. J. S. Morrill, resolution for placing in libraries.....	98, 108
Call for convention.....	16
Chemistry and Agriculture, minutes of section.....	129
report of section.....	36
College exhibit at World's Columbian Exposition, report of committee.....	103
statistics, committee to collate.....	24
work, officers of section.....	110
report of section.....	24
discussion on.....	52
Colleges, editing and publishing reports by Commissioner of Education.....	113
report of committee on statistics of.....	111
time and number of reports required.....	122
Comparative test of fungicides in checking potato blight and rot.....	89
Constitution of Association.....	7
revision.....	71
Convention, call for.....	16
invitation to hold at Ames, Iowa.....	125
in Texas.....	126
time and place of.....	21

	Page.
Conventions, resolution to confine programmes to administrative and experimental questions...	99, 109
Coöperation with U. S. Weather Bureau, report of committee	106
Courses of study, the relation of general to technical	67
Courtesies, committee for acknowledging	98, 103
Crossing of cucurbits.....	94
Delegates, list of.....	13
number of votes one may cast	72
Dues of institutions.....	108
Editing and publishing of reports of presidents of colleges by the Bureau of Education.....	113
of proceedings.....	112
Election of officers.....	109
Entomology, officers of section	110
report of section.....	41
Executive committee, report	21
Exhibit of stations at the World's Columbian Exposition, report of committee.....	99
Exhibit of colleges, report of committee.....	103
Experimentation, the establishment of official methods.....	147
Experiments in breeding.....	162
Forage plants for the semi-arid West.....	145
Fruit decays, a study.....	91
Fruits, notes on breeding.....	92
Fungicides, comparative test in checking potato blight and rot	89
Grass gardens, methods and purposes	130
Horticulture and botany, officers of section.....	110
minutes of section.....	167
report of section.....	52
Intercollegiate statistics, report of committee.....	111
Interior, Department of, relation of colleges to.....	114
Invitation to hold next convention at Ames, Iowa	125
in Texas	126
to organizations to sit as delegates	24
to visit Louisiana State University and A. and M. College.....	97
rice mills	124
Southern University.....	24
Irrigation, methods.....	142
Lectures in connection with agricultural exhibit.....	108
Length and number of sessions of convention.....	109
List of delegates and visitors	13
Live weight of an animal	150
Local programme.....	19
Mechanic arts, officers of section.....	110
section on	74
Methods of analysis of soils	158
irrigation.....	142
Minutes of section on Agriculture and Chemistry	129
Horticulture.....	167
Botany.....	168
Morrill, Hon. J. S., bust to be placed in libraries of agricultural colleges	98, 108
Nominating officers, committee on	103
Notes on the breeding of fruits	92
Office of Experiment Stations, card index of.....	125
resolutions on work of	124
Officers of Association	11
election of	109
committee for nominating	103
sections, election of.....	110
Official method of experimentation, the establishment of	147
Physical test of soils	156
Potato blight and rot, comparative test of fungicides in checking	89
President, annual address.....	58
Programme, general sessions	17
local.....	19
resolution to confine to experimental and administrative questions.....	99, 109
section on Agriculture.....	18
Botany.....	18

	Page.
Programmes of sections.....	18
Publications, station, numbering.....	80, 82
title-paging of	86
Purdue University, invitation to southern visitors en route to World's Columbian Exposition ..	125
Proceedings of convention, editing of.....	112
Ramie culture in the South	164
Regrets, letters of, from members	126
telegram from Assistant Secretary of Agriculture Willits.....	98
Relation of technical to general courses of study.....	67
Report of committee on Agricultural Congress at World's Columbian Exposition	104
coöperation with U. S. Weather Bureau	106
executive committee	21
section on Agriculture.....	28
Botany.....	33
College Work	24
Chemistry.....	36
Entomology.....	41
Horticulture	52
treasurer.....	24
Reports of presidents of colleges, time and number required by Department of the Interior	122
Representation, discussion on.....	72
Resolutions reported by executive committee	79
Revision of constitution.....	71
Schedule, appointment of committee to arrange with Bureau of Education for annual reports ..	121
discussion on form	116
Sections, programmes.....	18
Sessions of convention, number and length	109
Soils, physical tests.....	156
methods of analysis	158
Southern University, letter of invitation to visit	24
vote of thanks to officers.....	124
Station exhibit at World's Columbian Exposition, report of committee.....	99
literature, card index	125
publications, numbering	80, 82
Statistics of colleges and stations, committee to collate.....	24
report of committee on.....	111
Study of fruit decays.....	91
Suggested experiments in breeding.....	162
Test of dairy cows at World's Columbian Exposition—	
Committee.....	80, 85, 107
Resolution for editing and publishing results.....	98
Tests of soils	156
The bulletin, present and prospective	138
The establishment of official methods of experimentation	147
Thanks, resolution of, to the city of New Orleans, press, organizations, etc	124
vote of, to Southern University	124
Title, discussion on change of	76, 78
Treasurer's report, report of auditing committee	113
Treasurer, report of	24
Treatment of apple scab.....	87
U. S. Department of Agriculture, resolution of coöperation	112
Weather Bureau, report of committee on coöperation.....	106
What is the live weight of an animal?.....	150
shall the professor of agriculture teach?.....	139
World's Columbian Exposition, advisory board to committee.....	79, 85
agricultural congress, report of committee.....	104
coöperative station exhibit, report of committee.....	99
collective college exhibit, report of committee	103
dairy tests, record of.....	98
lectures in connection with agricultural exhibit	108
report of committee to select committee on test of dairy cows..	111
test of dairy cows, committee on.....	80, 85, 107

PUBLICATIONS OF THE OFFICE OF EXPERIMENT STATIONS.

The Office of Experiment Stations issues two classes of publications for general distribution:

(1) Experiment Station Record, Experiment Station Bulletins, and Miscellaneous Bulletins, which are more or less technical. It is the practice to send to persons applying for them one or more numbers, from which they may judge of their usefulness, but not to place any names upon the mailing list until after receipt of applications on special blanks furnished by the Office.

(2) Farmers' Bulletins, which are brief and popular in character, and are sent on application. These bulletins are issued as part of the general series of Farmers' Bulletins of the Department of Agriculture.

The following publications have been issued:

Experiment Station Record, vol. I, 6 numbers; vol. II, 12 numbers; vol. III, 12 numbers and index; vol. IV, Nos. 1-10. Copies of the station and Department publications abstracted in the Record can, in many instances, be obtained on application.

Experiment Station Bulletins.—No. 1, Organization and History of the Stations; No. 2, Digest of Annual Reports of the Stations for 1888, in two parts; No. 3, Report of Meeting of Horticulturists at Columbus, Ohio, June, 1889; No. 4, List of Station Horticulturists and Outline of their Work; No. 5, Organization Lists of Stations and Colleges, March, 1890; No. 6, List of Station Botanists and Outline of their Work; No. 7, Proceedings of the Fifth Annual Convention of the Association of American Agricultural Colleges and Experiment Stations, Washington, D. C., August, 1891; No. 8, Lectures on Investigations at Rothamsted Experimental Station; No. 9, The Fermentations of Milk; No. 10, Meteorological Work for Agricultural Institutions; No. 11, A Compilation of Analyses of American Feeding Stuffs; No. 12, Organization Lists of the Agricultural Experiment Stations and Agricultural Schools and Colleges in the United States, June, 1892; No. 13, Organization Lists of the Agricultural Experiment Stations and Agricultural Schools and Colleges in the United States, April, 1893; No. 14, Proceedings of a Convention of the National League for Good Roads.

Miscellaneous Bulletins.—No. 1, Proceedings of Knoxville Convention of Association of Agricultural Colleges and Stations, January, 1889; No. 2, Proceedings of Washington Convention of the Association, November, 1889; No. 3, Proceedings of Champaign Convention of the Association, November, 1890.

Farmers' Bulletins.—No. 1, The What and Why of Agricultural Experiment Stations; No. 2, Illustrations of the Work of the Stations; No. 9, Milk Fermentations and their Relation to Dairying; No. 11, The Rape Plant.

Communications intended for this Office should be addressed to the SECRETARY OF AGRICULTURE, for the Office of Experiment Stations, Department of Agriculture, Washington, D. C.

U. S. DEPARTMENT OF AGRICULTURE
OFFICE OF EXPERIMENT STATIONS

BULLETIN No. 17

SUGGESTIONS

FOR THE

ESTABLISHMENT OF FOOD LABORATORIES

IN CONNECTION WITH THE

AGRICULTURAL EXPERIMENT STATIONS

OF THE

UNITED STATES

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE

WASHINGTON
GOVERNMENT PRINTING OFFICE
1893

OFFICE OF EXPERIMENT STATIONS.

A. W. HARRIS, Director.
 A. C. TRUE, Assistant Director and Editor of departments of Botany, Field Crops, and Horticulture.
 W. O. ATWATER, Special Editor for Foreign Work.
 E. W. ALLEN, Editor of departments of Chemistry, Foods and Animal Production, and Dairying.
 W. H. BEAL, Editor of departments of Fertilizers, Soils, and Indexes.
 WALTER H. EVANS, Editor of departments of Seeds, Weeds, and Diseases of Plants.
 S. L. SOMMERS, Librarian and Record Clerk.

THE AGRICULTURAL EXPERIMENT STATIONS.

ALABAMA—<i>Auburn</i>: College Station; W. L. Broun.† <i>Uniontown</i>: Canebroke Station; H. Benton.† ARIZONA—<i>Tucson</i>: F. A. Gulley.* ARKANSAS—<i>Fayetteville</i>: R. L. Bennett.* CALIFORNIA—<i>Berkeley</i>: E. W. Hilgard.* COLORADO—<i>Fort Collins</i>: Alston Ellis.* CONNECTICUT—<i>New Haven</i>: State Station; S. W. Johnson.* <i>Storrs</i>: Storrs School Station; W. O. Atwater.* DELAWARE—<i>Newark</i>: A. T. Neale.* FLORIDA—<i>Lake City</i>: O. Clute.* GEORGIA—<i>Experiment</i>: R. J. Redding.* IDAHO—<i>Moscow</i>: C. P. Fox.* ILLINOIS—<i>Champaign</i>: G. E. Morrow.† INDIANA—<i>Lafayette</i>: C. S. Plumb.* IOWA—<i>Ames</i>: James Wilson.* KANSAS—<i>Manhattan</i>: G. T. Fairchild.§ KENTUCKY—<i>Lexington</i>: M. A. Scovell.* LOUISIANA—<i>Audubon Park, New Orleans</i>: Sugar Station. <i>Baton Rouge</i>: State Station. <i>Calhoun</i>: North Louisiana Station; W. C. Stubbs.* MAINE—<i>Orono</i>: W. H. Jordan.* MARYLAND—<i>College Park</i>: R. H. Miller.* MASSACHUSETTS—<i>Amherst</i>: State Station; C. A. Goessmann.* <i>Amherst</i>: Hatch Station; H. H. Goodell.* MICHIGAN—<i>Agricultural College</i>: L. G. Gorton.* MINNESOTA—<i>St. Anthony Park</i>: MISSISSIPPI—<i>Agricultural College</i>: S. M. Tracy.*	MISSOURI—<i>Columbia</i>: E. D. Porter.* MONTANA—<i>Bozeman</i>: S. M. Emery.* NEBRASKA—<i>Lincoln</i>: C. L. Ingersoll.* NEVADA—<i>Reno</i>: S. A. Jones.* NEW HAMPSHIRE—<i>Durham</i>: G. H. Whitcher.* NEW JERSEY—<i>New Brunswick</i>: State Station; E. B. Voorhees.* <i>College Station</i>: A. Scott.* NEW MEXICO—<i>Las Cruces</i>: H. Hadley.* NEW YORK—<i>Geneva</i>: State Station; P. Collier.* <i>Ithaca</i>: Cornell University Station; I. P. Roberts.* NORTH CAROLINA—<i>Raleigh</i>: H. B. Battle.* NORTH DAKOTA—<i>Fargo</i>: J. B. Power.* OHIO—<i>Wooster</i>: C. E. Thorne.* OKLAHOMA—<i>Stillwater</i>: J. C. Neal.* OREGON—<i>Corvallis</i>: J. M. Bloss.* PENNSYLVANIA—<i>State College</i>: H. P. Armsby.* RHODE ISLAND—<i>Kingston</i>: C. O. Flagg.* SOUTH CAROLINA—<i>Fort Hill</i>: J. S. Newman.¶ SOUTH DAKOTA—<i>Brookings</i>: L. McLouth.¶ TENNESSEE—<i>Knoxville</i>: C. F. Vanderford.* TEXAS—<i>College Station</i>: J. H. Connell.* UTAH—<i>Logan</i>: J. W. Sanborn.* VERMONT—<i>Burlington</i>: J. L. Hills.* VIRGINIA—<i>Blacksburg</i>: J. M. McBryde.* WASHINGTON—<i>Pullman</i>: E. A. Bryan.* WEST VIRGINIA—<i>Morgantown</i>: J. A. Myers.* WISCONSIN—<i>Madison</i>: W. A. Henry.* WYOMING—<i>Laramie</i>: A. A. Johnson.*
---	--

*Director.

†President of board of direction.

¶Acting director.

‡Assistant director in charge.

§Chairman of council.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., September 15, 1893.

SIR: In accordance with your instructions I transmit herewith, for publication, an article entitled "Suggestions for the Establishment of Food Laboratories in Connection with the Agricultural Experiment Stations of the United States," by the Hon. Edward Atkinson, of Boston, Mass., together with the accompanying prefatory note.

Very respectfully,

A. W. HARRIS,
Director.

Hon. J. STERLING MORTON,
Secretary of Agriculture.

PREFATORY NOTE.

The following paper (Suggestions for the Establishment of Food Laboratories in Connection with the Agricultural Experiment Stations of the United States), submitted by the Hon. Edward Atkinson, of Boston, Mass., is published as presenting a line of thought which is extremely suggestive, and seems to be strictly pertinent to the work of agricultural investigation inaugurated by the creation of the agricultural experiment stations in the several States.

The subject deserves earnest consideration and thorough discussion, to be followed in due time, it is to be hoped, by an earnest effort on the part of those American scientific investigators who are the best qualified, and endowed with the best facilities for the prosecution of such work, in completing the work of agricultural investigation heretofore largely devoted to elucidating the problems in the life and nutrition of plants and the lower animals, by the most thorough and careful research into the relations between man's nutrition and man's achievement.

In the meantime it is proper to state that the Department of Agriculture has already undertaken that part of the work which is indicated by Mr. Atkinson as the first thing to be done, namely, the collation of the results of foreign experiments in this line, in the hope that when all the information obtainable on this important subject has been gathered and digested by the best authority accessible on human nutrition, the Department will then be prepared to present the practical results of work already done to the people in concise and readable form, and secondly, to formulate a plan for further investigations by experts in the United States with special reference to the conditions and needs of our own people.

It is believed that a perusal of Mr. Atkinson's suggestive paper will serve to impress the reader with the importance of the subject and its value to humanity, as well as to convey some idea of the difficulties to be met and overcome in a solution of the problems involved.

J. STERLING MORTON,
Secretary.

SEPTEMBER 15, 1893.

SUGGESTIONS FOR THE ESTABLISHMENT OF FOOD LABORATORIES IN CONNECTION WITH THE AGRICULTURAL EXPERIMENT STATIONS OF THE UNITED STATES.

By EDWARD ATKINSON.

In dealing with this subject, the undersigned sets up no claim to any complete scientific training. His vocation has been to compile and collate the data of science in regard to nutrition, in order to determine how far the discoveries of science have been converted into a common and easily practiced art.

Had the human race waited for the development of a science of nutrition, mankind would have suffered from starvation, as if men had not used a spoken language until they knew the rules of grammar.

All applied science must be based on experience and natural selection. Each race, each country, and almost each section of each country, through a process of natural selection, appears to have reached a unit of food, simple or compound, in which "the nutrients," so-called, are to be found in about the right proportion. Each of these food units has been produced or combined in such a manner as to assure the maximum of nutrition at the least cost. Among the poorest nations and among the poorest people the art of nutrition appears to be better comprehended than among the more prosperous races or states, and especially among the most prosperous class in each community. The people of this country are the most wasteful in the world.

The following examples of substantially complete national foods, combining the principal nutrients—nitrogen, starch, and fat—in substantially right proportions, are cited in proof of the foregoing statement. It will be observed that where the supply of meat is deficient the nitrogenous element in food is provided for in the consumption of leguminous plants and cheese.

1. England: Wheat bread with cheese rather than with butter.
2. Scotland: Oatmeal, milk, and salt.
3. France: Soups and stews containing a large element of leguminous plants—beans, peas, lentils, etc.
4. Italy: Macaroni made from wheat, and polenta made from maize, cooked with cheese made from skim milk.
5. India and China: Rice combined with beans or peas.

6. Japan: The common food called "miso," compounded of rice and barley fermented, with beans or peas.

7. Canada: Porridge made of dry peas, coarse wheat crackers, savory herbs, and a little pork.

8. New England: Baked beans and brown bread, or codfish balls, salt pork, and potatoes.

9. The creoles of New Orleans: Rice and red beans.

10. The blacks of the South: Bacon, corn meal, and molasses.

To the uninstructed mind the nutrition of the soil, of the plant, of the beast, and of the man, appears to follow practically uniform rules. It consists in the right conversion of certain elements which in the plant, the beast, and the man, are derived from air, water, and soil, into compounds; these compounds have been named nutrients. When dealing with the consumption of food by animals, these nutrients have been divided into: First, protein, the albuminoid or nitrogenous compound; second, carbohydrates, or the starchy compound; third, fats. To these are added certain mineral elements of food which need not be dealt with in this rough and ready form of analysis, as they are found in sufficient measure in almost all kinds of food.

Now while there is among uninstructed people an apparently wide but somewhat indefinite knowledge of the general processes of nutrition derived from experience, there appears to be an absence of the exact knowledge of the relative proportions in which plant, beast, and man are nourished by means of soil, air, and water.

Dealing first with the soil, it would appear that the elements for the fertilization of specific soils can be determined only through a right knowledge of the inherent properties of the soils and the general conditions of heat, moisture, and other physical agencies in each of the various localities. If I am rightly informed, greater progress has been made in this matter in Prussia and perhaps in some other parts of Germany than anywhere else. Soils have been graded, described, classified, numbered, and registered, so that the prospective purchaser may learn their relative value, and to some extent the properties or elements of fertility present or required in each kind of soil. He may, therefore, determine what kind of crops he can raise upon it, and what specific kind of fertilizer will be needed to make the most abundant product. Herein perhaps lies the greatest value of the agricultural experiment stations of this country.

Due consideration having thus been given, which may lead to the right method at the least cost for fertilizing the soils with a view to the production of plants, we next come to the nutrition of the beast. In this matter there appears to be little variation. It must be accomplished within strict and easily defined limits, many of which are substantially established, although the reasons have not as a rule been given, nor are the proportions of the nutrients in each kind of food fully comprehended. The specific theories of how to nourish trotting horses, mules, beeves for flesh, cows for milk, and hogs for pork, are now

fairly well established, very largely through the intervention of the experiment stations. The varieties of food can be dogmatically stated but the reasons for the variation and the exact proportions of the several nutrients are not commonly known. It follows that discussions of this subject in nearly all the agricultural papers are vague. They lack the definiteness of a science. The right nutrition for sheep with a view to the relative production of carcass or wool does not yet seem to be well comprehended.

THE TRUE WORK OF THE FOOD LABORATORY.

Neither the conversion of what are now waste products to the nutrition of animals nor the conversion of food so that there will be little waste is yet well comprehended. There has been some progress in the conversion of the waste products of the animal itself to useful purposes, but it is confined mainly to great establishments. In many parts of the country there is a very great waste of food before the food is distributed, and yet greater waste in the domestic kitchen. This subject of waste may be developed in a complete and scientific manner. The rules of nutrition or the proportions of the nutrients required may be established so as to be taught in every common school. The science of human nutrition may become an art. To this end the relative proportions of the nutrients which are combined in the various plants having first been established, they may be put in tabular form. Then the use of these food plants in due proportion may so far be made a matter of rule that the exceptions may be mastered by persons of common intelligence. For instance, the development of the silo and the feeding of animals with silage has been very recently introduced in this country. It is now well known that the greater bulk of the food put into the silo may be maize or cornstalks and the condition or point of growth at which they should be put into the silo above or below ground has become well established. It is also well known that corn fodder by itself is not a complete food because it is deficient in the nitrogenous element. There are a great many leguminous plants which can be grown with the maize, such as the cowpea, clover, buckwheat, and others. Now if tables are given of the general standard of nutrition, accompanied by tables giving the usual proportion of the nutrients in maize and in each type of legume, the silo can be filled by anyone in sufficiently exact proportions to make the food complete. One of my correspondents, now deceased, in North Carolina, learned this lesson for himself. He so combined cornstalks and pea vines in the silo as to make a complete food for working horses and mules at a cost of less than \$2 per ton, 2 tons of silage being equal to 1 ton of the best hay. From these well established rules of proportion it would become a very simple matter to lay off the farm, with the right number of acres of corn and the right number of acres of pea vines or of clover, in order that the silage from a given area might contain nitrogen, starch, and fat, in sub-

stantially true proportions. Again, these proportions may be changed according to the purpose, whether to make fat, meat, or milk.

The investigations which have been made in this country, notably by Prof. W. O. Atwater, indicate that our national dietary is very one-sided. The farmer and the consumer both lose heavily in consequence. We produce relatively too much fat, starch, and sugar and too little protein.

Again, might not the art of combining skim milk with the refuse of the gristmill be so established as to make a complete food for poultry, and perhaps for cows? A half-pound of chaff, giving bulk, combined with 4 pounds or pints of skim milk, with a little lime and a little molasses or syrup added to make saccharate of lime, evaporated slowly by heat into a porridge, makes a complete food for hens for the production of eggs as well as flesh. This has been established. Chaff of any kind and skim milk cooked together at a low heat can be made into what may be called cow bread, thus restoring to the cow all the solids which had been derived from the soil in the production of milk, and finally returning them to the soil.

Now, while there are many known data, and while our rules have been or may be established for the nutrition of beasts and of poultry, have we as yet established the data for the nutrition of mankind to anything like the same extent? Is it consistent to expend large sums of money on agricultural experiment stations to the end that the largest production of the best kind of food may be brought about at the least cost, while we utterly neglect the most important department, viz, the right conversion of this material to the use of mankind? Do we not as a nation convert the most abundant supply of the best food material into bad feeding through our general ignorance of the processes of cooking? There is yet no popular science of cooking. There is yet no common art of cooking. There is now widespread ignorance on the whole subject, resulting in a waste which is not only unprofitable but noxious in its influence on the general health of the community.

The science of cooking consists in the right application of heat at the right temperature or degree of heat for the right time to the various elements of food. To what well-known popular treatise can anyone refer in which this art is taught? Of what do the rules laid down in the innumerable books on cooking mainly consist? Do they not consist in empirical instructions how to surmount the faults of the common cooking stove or range? Mankind makes use of a greater variety of food materials than any other class of animals, but there is less variation in the right nutrition of man than exists in respect to the soil, the plant, or the beast. The nutrition of man is more simple, more capable of being established by rule; the variation may consist more in the quantity than the kind of food, so as to meet the demands of the work done and of the season. All these variations are capable of being

established under very simple rules. It has proved to be a very simple matter to lay out dietaries or rations for one or more days, consisting of the common articles of food at customary prices. The quantity only may be varied according to the age, sex, or according to the kind of work for which the food is required to provide the requisite energy. As a rule, the difference between the man and the beast is that the larger portion of the food of the man is cooked; the lesser portion being consumed as it comes from the field. The following examples are given, which substantially depend upon how they are cooked for the amount of energy which may be derived from them. The two examples are taken from the *Science of Nutrition*, a treatise prepared by the author of this article, and published by Messrs Dammell & Upham, Boston. In it are given many examples of complete dietaries for thirty days, varying in cost. The dietaries of lowest and of highest cost are selected. The constants in all the dietaries consist of grain, vegetables, and sugar; the variables consist of meat, poultry, milk, and leguminous plants. The prices given are those of the Boston market at the date of compilation:

DIETARY No. 2.

Materials.	Quantity.	Cost per pound.	Total.	Calories.
CONSTANTS.				
	<i>Pounds.</i>			
Flour.....	22	\$0.02½	\$0.55	.....
Oatmeal.....	3	.04	.12	.....
Corn meal.....	3	.03	.09	.....
Hominy.....	6	.04½	.27	.....
Butter.....	2	.28	.56	.....
Suet.....	2	.06	.12	.....
Potatoes.....	10	.02½	.25	.....
Cabbage.....	3	.03	.09	.....
Carrots.....	2	.02½	.05	.....
Onions.....	2	.05½	.11	.....
Sugar.....	2	.05	.10	.....
Total	57	.....	2.31	79,770
VARIABLES.				
Beef or mutton	10	.06	.60	.....
Eggs (1½ dozen).....	2	*.18	.27	.....
Beans and peas.....	8	.07	.56	.....
Skim milk.....	15	.02	.30	.....
Suet.....	2	.06	.12	.....
Total	37	.....	1.85	29,925
Total for 30 days.....	94	.....	4.16	109,695
Total for 1 day.....	3.1	.....	.139	3,656.5

Cost per week, 97.3 cents.

*Per dozen.

DIETARY No. 12.

Materials.	Quantity.	Cost per pound.	Total.	Calories.
CONSTANTS.				
	<i>Pounds.</i>			
Flour.....	22	\$0.02½	\$0.55	.....
Oatmeal.....	3	.04	.12	.....
Corn meal.....	3	.03	.09	.....
Hominy.....	6	.04½	.27	.....
Butter.....	2	.28	.56	.....
Suet.....	2	.06	.12	.....
Potatoes.....	10	.02½	.25	.....
Cabbage.....	3	.03	.09	.....
Carrots.....	2	.02½	.05	.....
Onions.....	2	.05½	.11	.....
Sugar.....	2	.05	.10	.....
Total.....	57		2.31	79,770
VARIABLES.				
Beef, sirloin.....	6	.25	1.50	.....
Leg mutton.....	4	.20	.80	.....
Lamb or veal.....	4	.15	.60	.....
Fresh fish.....	6	.15	.90	.....
Eggs (2½ dozen).....	3	*.24	.54	.....
Butter.....	2	.30	.60	.....
Whole milk.....	15	.03	.45	.....
Beans.....	2	.07	.14	.....
Peas.....	2	.07	.14	.....
Rice.....	2	.06	.12	.....
Tapioca.....	2	.09	.18	.....
Farina.....	1	.03	.09	.....
Sugar.....	3	.05	.15	.....
Total.....	56		6.27	50,320
Total for 30 days.....	113		8.58	130,090
Total for 1 day.....	3.70		.286	4,336.3

* Per dozen.

Cost per week, \$2. This dietary contains a customary but unwholesome quantity of sugar.

Dietary No. 2, containing the protein in the form of the cheaper cuts of meat, beans, peas, and the cereals, and carbohydrates in the form of starch, will depend wholly upon the method of cooking, first, as to whether or not it can be eaten; second, as to whether or not it can be digested. No. 12, which contains the elements of nutrition in the same proportion, but in greater variety of food material is yet liable to be so combined in unwholesome dishes or to be so badly cooked as to be sent away only tasted but not consumed. One may be underfed on the most expensive as well as the least expensive dietary; all depends upon the right application of heat at the right degree of temperature for the right time.

A much more thorough investigation is needed in respect to the digestibility of food when prepared in different ways than has yet been given to it. A great deal of work has already been done, and the methods of experimenting are tolerably well elaborated. What is now required is to collate the results of these experiments, most of which are to be found in foreign publications that have not yet been made properly accessible to English readers. Further experiments are required, which must be more systematic and extensive than anything thus far attempted. The work, thus far, has been that of individuals,

taken up in a disjointed way without any special system. The coöperation of a large number of workers investigating on a common plan is required. There are methods of what is called artificial digestion, *i. e.*, treating food by solvents similar to those which act in the human body. Other experiments may consist in feeding men and animals by measure and analysis. Experiments of both these kinds have been made in Europe and a few have been carried on at the experiment stations of the United States, but the results have not yet been compiled and tabulated here.

An example of the practical application of these investigations is to be found in the German army sausage—a complete food in the least bulk—needing only water and a little heat for its conversion into a full and digestible ration.

In support of these views a few familiar examples may be given of the effect of measured heat.

The coffee berry.—If this berry is ground and made into an infusion without roasting it is worthless. If it is roasted too much so as to be nearly carbonized, it is also worthless. If subjected to a uniform heat at the right degree for the right time, then subjected to infusion, we have coffee.

Eggs.—If an egg is subjected to a boiling heat 10 minutes the yolk becomes mealy and the white becomes horny and indigestible. If subjected to heat at about 180°F. for 10 minutes, both yolk and white become of the consistency of jelly and are exceedingly nutritious and digestible.

Potatoes.—If potatoes are subjected to a little less than a boiling heat they are cooked but not in an appetizing or digestible manner. If cooked by boiling or by baking at a higher heat, the starch cells are burst and they become mealy and digestible.

Meats.—If tough meat be boiled long enough the fibers may be separated and the juices extracted, but each fiber will be tough and horny. If the same meat be subjected to a heat of about 190°F. for a suitable time the fiber itself is disintegrated or dissociated, the juices may be retained and the whole substance becomes tender and digestible. One of the toughest muscles is the beeve's heart. By the long application of a moderate degree of heat in a closed vessel it may be made more tender than the tenderloin.

Fats.—When fats are subjected to a heat high enough to distill or “crack” them, as it is termed, the volatile portions are diffused in the atmosphere making bad odors, while the heavier portions are often rendered indigestible. The same fat, subjected to a degree of heat less than the distilling or cracking point, is converted into a very necessary element of food which may be completely assimilated when consumed in the right proportion.

Beans and peas.—When cooked for a long time at a moderate heat, beans and peas are not only more digestible but have a flavor which is

utterly wanting when they are subjected to a high degree of heat for a short time. The appetizing merit of the old-fashioned brick oven was due to the low degree of heat developed and applied for many hours.

Wheat bread.—Bread from one half a batch of dough, baked quickly at a high heat may be very light, very white, and very tasteless. The other half baked twice as long at a low heat will be as light, creamy in color, and full of flavor. The first batch will dry up or mold speedily; the second will keep in an appetizing and nutritious condition for many days.

Peanuts.—These nuts must be baked or roasted before being eaten. When treated for the extraction of oil they are first heated to a certain temperature. The kernel contains 50 per cent oil, 24 per cent albuminoids.

The art of cooking as now practiced is wholly empirical and to a great extent bad. Almost all rapid or quick cooking is bad cooking. The science of cooking, as I have stated, consists in the regulated application of the right degree of heat for a suitable time to work the true conversion of the raw food materials into nutritious food. If there is a variation of any considerable amount in either of these elements, *i. e.*, in the uniformity or degree of heat or in the time of its application, the cooking will as a rule be bad. For instance, if animal foods are subjected to an excessive heat as they are apt to be in the frying pan and in the cooking stove, they become more productive of dyspepsia than of energy. The development of a food laboratory may therefore be directed toward the right methods of preparation of the food of mankind. Unless that object is incorporated with the other work of the experiment stations, they may totally fail in their true object, which is the final conversion of the nutrients in food material to the nutrition of mankind.

The wealth and progress of a nation depend not only on quantity but also on quality in its production. Even the quality may fail of its purpose if the science of consumption is not developed so as to assure a reproduction of the maximum amount of energy. In the period before the development of steam, the implements of civilization were drawn by the slow, ill-fed team of oxen; progress was slow and the increase of wealth very slight. When the stored up energy of the coal fields was utilized in the swift locomotive, progress was correspondingly rapid, and the increase in wealth kept pace with it.

Human energy is only one link in the correlation of forces. Its source is the same ultimately as that of the ox and of the locomotive, namely, chemical decomposition and recombination. There is nothing mysterious about it. The manifestations of human energy are in two forms, that of purely mechanical and muscular work—the trench digger; and that of skill or mental power, directing the mechanical power, and thus rendering it tenfold more effective—the skilled mechanic, the inventor, the writer, the thinker.

The source of this human energy, in whatever form it manifests itself, is the same, namely, the chemical reactions in the body, dependent upon the food eaten. A given amount of food may produce a given amount of trench digging, or a new invention, or a poem. Whatever else is necessary, the food must not be lacking.

Under what conditions this energy which is obtained from food can be best utilized is perhaps the most important unsolved problem of the age. This country waits for a true science of nutrition. If it is sound policy for the Government to appoint a commission to determine how to lessen the waste of our store of coal, from which we derive mechanical power, it is surely as sound policy to spend a little money for the prevention of waste of the human energy, viz, the waste of our food supply. The causes of waste are to be looked for in special directions. In the case of the steam engine, it is in the imperfect combustion or waste of coal. The waste of human energy is to be found in the misuse or waste of food materials and also in the waste of food by bad cooking. Improper nutrition not only causes a waste of energy, but it is injurious to the machine itself in which the energy is produced; it is the cause of disease in the human body. The lines of investigation which ought to be considered are, first, the best means to produce the highest amount of human energy with the least waste; that is to say, the best form in which food materials are to be consumed; how far can predigestion outside the body take the place of work done in the body without detriment to the machinery. Another line of investigation may be the following: If a simple, monotonous food is best for the animal, is a greater variety, and especially are stimulating flavors, better for the mental work of the human thinker than for the muscular work of the human animal? Or perhaps this problem might be reversed; may not the human animal be developed into a higher type of the human thinker by developing right methods in the choice of food, and in its preparation? These are perhaps somewhat visionary suggestions. They are put in this form in order to give point to the suggestions submitted. Third, what is the relation of physical exercise, apart from work, to the nutrition of the body as an instrument of thought? The number of problems which may be presented for solution in this matter is very great. We have nothing to do with the source of energy, the sun. We have to do with the conservation of this energy. We have yet much to learn of the best means of conserving and utilizing the best thought in the world.

It may be assumed that the students in the agricultural colleges, to which agricultural experiment stations are attached, are thoughtful men, observers, and investigators. They may themselves become the subjects of observation. They may develop a true art of applying heat to the conversion of nutritious food. They may vary the preparation of the nutrients and they may establish by observation, each upon himself and upon his fellow students, the method of nutrition which

serves in the best manner the development of the activities of the student.

If the law will not now permit the application of the funds appropriated to agricultural experiment stations to the study of the nutrition of the human animal, then it might be judicious to call upon Congress to pass an amendment to the law, which might perhaps be well accompanied with a small additional appropriation in order to complete the service and to round out the whole science of nutrition by including the nutrition of mankind as a final object of the whole work.

The importance of this matter as an element of national welfare can not be exaggerated. There are precedents to justify such a course in the work done in other countries. In many countries upon the continent of Europe, notably in Germany and in Italy, the continuous pressure of passive war, the withdrawal of great numbers of men in the prime of life from productive industries, who must be sustained by taking from the working people the most necessary portion of their food product, has compelled the attention of paternal governments to be given to this subject lest the pressure of want should culminate in revolution. Under these conditions very great progress has been made in the development of the science of nutrition, notably in Germany; and many undertakings have been experimented with in diffusing a knowledge of the right use of food materials. Very important information could be obtained from our foreign ministers and consuls upon this subject in response to carefully framed questions. The consular reports already made have contained very valuable information. The heads of great industrial establishments have interested themselves in the matter; one of the principal elements in the contest between the more conservative members of society and the socialists in Germany being the resistance of the socialists to the beneficial undertakings or "patronage" of the heads of private establishments; their contention being that the state and the state only should provide for the common welfare of the people even in such matters as these.

The motive in this country for conducting this work would be something very different from the motives which actuate foreign governments. Nevertheless, the information which could be obtained in many quarters about what has been accomplished in Europe would be of the greatest service in directing our own course.

The chief end in European investigation has been to bring about economy in the consumption of food material, economy in the use of fuel being enforced by scarcity. Scarcity of fuel is one prime cause of the superiority of foreign cooking over our own. The French and Italians are compelled to get the most complete results from the minimum of fuel. They can not waste it in frying and broiling or in the high heat of our cooking stoves. Our very abundance of fuel is one of the causes of waste, both of food material and of the fuel alike. It would not be suitable to cite examples of ordinary cooking in a treatise

of this kind, but some general considerations or examples may be submitted.

Before dealing even with these examples I may again present the facts which have so often been urged. With respect to 90 per cent of the population of this country it has been conclusively proved that from 40 to 60 per cent of the average income of each family is expended in the purchase of food material. In the eastern part of this country the average expenditure of income for food of working people, or people in receipt of moderate incomes, is one-half. In the West, where food is more abundant, it is somewhat less. The proportion expended by common laborers for their family supply often reaches 60 per cent of their entire earnings. The subject to be dealt with and developed in the food laboratories, therefore, affects that element of expenditure which costs the most and in which there is the greatest waste.

If it should be found expedient or should be made lawful to establish food laboratories in connection with the agricultural experiment stations, it would be essential to make a beginning in what might be called experiment stations in the preparation of food, to accompany or even to precede a true food laboratory.

In these experimental cooking establishments food material would be dealt with practically according to the right theory of composition and combination resulting from laboratory work, and again, the laboratory work would be checked and in some measure directed by the practical results of the experimental cooking, the tests being made upon the students in the agricultural colleges with which the stations are connected. The failure of so many apparently sound theories of nutrition has been due to this lack of practical coöperation. It is not only necessary to furnish a wholesome diet of known nutritive value, but the taste of the consumers must be educated lest they should reject that which is wholesome and retain that which is called for by a depraved or uneducated appetite.

On what model might these food experiment stations or cooking establishments be established? The only example of a food experiment station known to me which has been brought to a successful and self-sustaining point is the New England Kitchen in Boston, Mass. The laboratory work in connection with this station has been of necessity limited, and the work has been made possible only through the courtesy of the chemical department of the Massachusetts Institute of Technology. This establishment has been under the responsible direction of Mrs. Ellen H. Richards, who has given me the following data in support of the suggestion which I have made in this memorandum:

The capital was furnished by charitable persons, who were willing to take the risk with a view to establishing a kitchen on a self-sustaining basis. The plant now serves food for about 1,000 noon lunches and 300 suppers each day, besides miscellaneous sales of bread, of milk, and of broth specifically prepared for the sick.

The total area of the bakery, of the kitchen, and of the basement is about 2,000 square feet. Both the apparatus and the space occupied might be utilized for double the amount of work if a second set of help were employed.

The outfit consists of one Middleby oven; ten Aladdin ovens; three gas stoves; one gas table designed expressly for the kitchen; one gas water heater; a small upright boiler which runs four steam jacketed kettles; one open steamer; one hot-water boiler and the radiator; various cooking kettles, pans, dishes, etc.; tables for the preparation of the food, and a plain counter for the sale of the product.

This outfit cost about \$1,500. The experimental work required to perfect both instruments and apparatus, with the skilled supervision necessary for a long period in the development of this work, cost in all \$5,000. The product of this work consists mainly of the knowledge of which the kitchen is ready to become the almoner.

The materials used are the best quality of the least expensive food substances, such as the neck and shin of beef, the cereals, beans, peas, and other legumes. The products are soups, stews, pressed meats, bread, especially that made of whole wheat, and a variety of simple dishes.

None of the food is eaten on the premises. The patronage once gained is retained, and the favorable comments often made encourage the belief that slow but steady progress is being made in teaching the art of nutrition among a considerable number of people who had very little knowledge of the right use of food before this experiment station was established.

U. S. DEPARTMENT OF AGRICULTURE
OFFICE OF EXPERIMENT STATIONS
BULLETIN No. 18

A CONTRIBUTION TO THE INVESTIGATION

OF THE

ASSIMILATION OF FREE ATMOSPHERIC NITROGEN

BY

WHITE AND BLACK MUSTARD

BY

J. P. LOTSY, Ph. D.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE

WASHINGTON
GOVERNMENT PRINTING OFFICE
1894

OFFICE OF EXPERIMENT STATIONS.

A. C. TRUE, Director.

E. W. ALLEN, Assistant Director and Editor of departments of Chemistry, Foods and Animal Production, and Dairying.

W. H. BEAL, Editor of departments of Meteorology, Fertilizers, Soils, and Indexes.

WALTER H. EVANS, Editor of departments of Botany, Seeds, Weeds, and Diseases of Plants.

J. F. DUGGAR, Editor of departments of Field Crops, and Veterinary Science and Practice.

W. O. ATWATER, Special Agent.

F. W. WOLL, Special Agent.

F. H. HALL, Librarian.

S. L. SOMMERS, Record Clerk.

THE AGRICULTURAL EXPERIMENT STATIONS.

ALABAMA—*Auburn*: College Station, W. L. Brown.† *Uniontown*: Canebrake Station; H. Benton.‡

ARIZONA—*Tucson*: F. A. Gulley.*

ARKANSAS—*Fayetteville*: R. L. Bennett.*

CALIFORNIA—*Berkeley*: E. W. Hilgard.*

COLORADO—*Fort Collins*: Alston Ellis.*

CONNECTICUT—*New Haven*: State Station; S. W. Johnson.* *Storrs*: Storrs School Station; W. O. Atwater.*

DELAWARE—*Newark*: A. T. Neale.*

FLORIDA—*Lake City*: O. Clute.*

GEORGIA—*Experiment*: R. J. Redding.*

IDAHO—*Moscow*: C. P. Fox.*

ILLINOIS—*Champaign*: G. E. Morrow.†

INDIANA—*La Fayette*: C. S. Plumb.*

IOWA—*Ames*: James Wilson.*

KANSAS—*Manhattan*: G. T. Fairchild.§

KENTUCKY—*Lexington*: M. A. Scovell.*

LOUISIANA—*Audubon Park, New Orleans*: Sugar Station. *Baton Rouge*: State Station. *Calhoun*: North Louisiana Station. W. C. Stubbs.*

MAINE—*Orono*: W. H. Jordan.*

MARYLAND—*College Park*: R. H. Miller.*

MASSACHUSETTS—*Amherst*: State Station; C. A. Goessmann.* *Amherst*: Hatch Station; H. H. Goodell.*

MICHIGAN—*Agricultural College*: L. G. Gorton.*

MINNESOTA—*St. Anthony Park*: W. M. Liggett.§

MISSISSIPPI—*Agricultural College*: S. M. Tracy.*

MISSOURI—*Columbia*: E. D. Porter.*

MONTANA—*Bozeman*: S. M. Emery.*

NEBRASKA—*Lincoln*: C. L. Ingersoll.*

NEVADA—*Reno*: S. A. Jones.*

NEW HAMPSHIRE—*Durham*: G. H. Whitcher.*

NEW JERSEY—*New Brunswick*: State Station; E. B. Voorhees.* *College Station*: A. Scott.*

NEW MEXICO—*Las Cruces*: H. Hadley.*

NEW YORK—*Geneva*: State Station; P. Collier.* *Ithaca*: Cornell University Station; I. P. Roberts.*

NORTH CAROLINA—*Raleigh*: H. B. Battle.*

NORTH DAKOTA—*Fargo*: J. B. Power.*

OHIO—*Wooster*: C. E. Thorne.*

OKLAHOMA—*Stillwater*: J. C. Neal.*

OREGON—*Corvallis*: J. M. Bloss.*

PENNSYLVANIA—*State College*: H. P. Armsby.*

RHODE ISLAND—*Kingston*: C. O. Flagg.*

SOUTH CAROLINA—*Fort Hill*: E. B. Craighead.*

SOUTH DAKOTA—*Brookings*: L. McLouth. ||

TENNESSEE—*Knoxville*: C. F. Vanderford.**

TEXAS—*College Station*: J. H. Connell.*

UTAH—*Logan*: J. W. Sanborn.*

VERMONT—*Burlington*: J. L. Hills.*

VIRGINIA—*Blacksburg*: J. M. McBryde.*

WASHINGTON—*Pullman*: E. A. Bryan.

WEST VIRGINIA—*Morgantown*: J. A. Myers.*

WISCONSIN—*Madison*: W. A. Henry.*

WYOMING—*Laramie*: A. A. Johnson.*

* Director.

† President of board of direction.

‡ Assistant director in charge.

§ Chairman of council.

|| Acting director.

** Secretary.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., December 16, 1893.

SIR: I transmit herewith for publication as Bulletin No. 18 of this Office an article describing the methods and results of an investigation regarding the assimilation of the free nitrogen of the air by two species of mustard. This investigation has been carried on by J. P. Lotsy, PH. D., Associate in Botany at Johns Hopkins University. There is at present great interest among scientific and practical agriculturists in everything which relates to the problem of the assimilation of atmospheric nitrogen by plants, and it is believed that the careful work reported in this bulletin will be of service, not only because of the results attained, but also by stimulating more thorough and rigorous inquiries on this great question.

Respectfully,

A. C. TRUE,
Director.

Hon. J. STERLING MORTON,
Secretary of Agriculture.

THE ASSIMILATION OF FREE ATMOSPHERIC NITROGEN BY WHITE AND BLACK MUSTARD.

By J. P. LOTSY, Ph. D.

The question whether the higher plants are able to assimilate the free atmospheric nitrogen is a problem which has been treated again and again. Since Boussingault's classical experiments the possibility of an assimilation of free nitrogen by the higher plants has been discarded by nearly all botanists, and only very few of them, like Frank and his associates, claim that most, if not all, plants possess this property. The question is of vital importance from an economic as well as a scientific standpoint. If it could be proved that our present notions of the inability of plants to assimilate free nitrogen were wrong, there would be radical changes in the use of artificial nitrogenous manures. The experiments made by Frank and others, which indicated that plants of different kinds could assimilate free nitrogen, are far from conclusive. Frank himself has never published his methods in sufficient detail to allow of criticism. For this reason the experiments reported in this bulletin were made. Before going into the question more in detail, it is desirable to explain why the mustard species were chosen for these experiments. The reason is that recently in many European agricultural papers it has been suggested that the mustards were able to enrich the soil in nitrogen. Now, experience teaches us, for example, in the case of the assimilation of free nitrogen by the *Papilionaceæ*, that practice very often recognizes facts before science is able to explain them. That others followed about the same course of reasoning becomes clear from the fact that recently, after my work was under way, some papers appeared which gave accounts of experiments with the same plants.

Before describing the experiments it will be well to consider in some detail the methods most frequently used by botanists to determine the assimilation of free nitrogen by plants, since the different methods strictly taken do not answer the same question. Hellriegel and his associates attack the problem of the assimilation of free nitrogen in this way: They begin by keeping away from the plants all sources of fixed nitrogen. The seeds are sprouted in distilled water, cultivated in

sand, which has been heated to redness and has been washed with acids, and finally are watered with carefully prepared nitrogen-free food solutions and distilled water. If the plant grows and shows upon chemical analysis more nitrogen in its substance than was contained in the seed the conclusion is drawn that the plant assimilates free nitrogen.

Frank and his associates approach the question in a fundamentally different manner. The seeds are sprouted in the same way, but then the plant is not put in a soil free from nitrogenous salts, but in a soil which possesses a certain known amount of nitrogenous substance. If it is known, for example, that 3 grams of fixed nitrogen were put into the pot, and that the seed contained 0.5 gram, then the nitrogen stock of the plant would be $3 + 0.5 = 3.5$ grams. If analysis at the end of the experiment shows the presence of 1.5 grams in the soil and 2 grams of fixed nitrogen in the crop, $1.5 + 2 = 3.5$ grams will be the total fixed nitrogen present, or the same amount as in the beginning of the experiment. It is thus made to appear that the plant had no need of an assimilation of free nitrogen. Whether it did or not remains to be seen, as fixed nitrogen present at the beginning of the experiment may have been decomposed, and free nitrogen fixed by the plant added. If, on the other hand, the soil contained 3 grams and the crop 2.5 grams, 5.5 grams would be the total fixed nitrogen at the end of the experiment. The 2 grams of additional fixed nitrogen can only have come from the atmosphere.

In the method used by Schlösing, the plant is cultivated in an air-tight glass chamber into which air free of ammonia is introduced. By analyzing this air before and after the growth of the plant, it can be determined whether there is a decrease in the amount of nitrogen or not. This method is by far the most direct one, but very great difficulties are encountered in carrying out the experiments.

Now let us see what different questions are answered by these methods strictly taken. The first method simply shows whether the plant is able to take *all* the nitrogen it needs from the atmosphere. The second method gives no results whatever in case the crop has no more nitrogen than was contained in the seed and soil; but in case there is an increase, it shows that the plant is able to supply itself partly with free nitrogen, but does not indicate whether the plant can live on free nitrogen exclusively, as it has some fixed nitrogen to start with. The third method may answer both questions. This will depend on the existence or not of fixed nitrogen in the soil at the beginning of the experiment. Even this method is, however, not entirely free from objections, on account of the fact that the plants have to be cultivated under unusual conditions, owing to the limited space in which they grow.

To get a clear insight into the question of the assimilation of free nitrogen, there remains conclusively but one thing to be done, viz, apply all three methods to the same kind of plant in each case. It is, in fact, possible that a plant may only be able to assimilate free nitro-

gen, if fixed nitrogen is present, or that at least only under those circumstances (Frank even claims this) is the assimilation of free nitrogen of practical value. It is furthermore possible that the plant may need fixed nitrogen during a certain period of its life, say during the young stage* as a seedling.

Not even after we have applied all three methods to the same plant and have invariably found that the plant assimilates free nitrogen, are we sure that our interpretation of the facts is correct. Microörganisms present in the culture media may have assimilated the free nitrogen, and the plants may have used this fixed nitrogen which originated entirely without their aid. The only way to overcome all difficulties is to grow plants by all three methods, using two parallel series in each case, one sterilized and the other unsterilized. This is tedious work, no doubt, but it is the only way to come to a well-founded conclusion.

The publication of accounts of certain recent experiments on the free assimilation of atmospheric nitrogen has made it advisable to issue this bulletin before tests by all three methods were completed.

Liebscher (*Journal für Landwirthschaft*, 1893) has published a report on some investigations carried on by the second method, in which it appeared that the mustard assimilated free nitrogen. The experiments here reported gave an opposite result, which, however, does not interfere directly with Liebscher's results, as his experiments do not answer the same question as those of the author. Liebscher's experiments have received much attention from agriculturists but need confirmation before field experiments on a large scale are attempted. His methods were not as rigorous as is desirable. For example, his plants were not watered with distilled water absolutely free from nitrogen, but with hydrant water which he himself admits contained some nitrogen.

Two articles by B. Frank (*Deutsche Landw. Presse*, 1893; *Botanische Zeitung*, Sept. 16, 1893, in detail) concern us more particularly. Frank claims that plants cultivated in sand absolutely free from fixed nitrogen show an increase in nitrogen, though very much less than when fixed nitrogen is present in the soil. He admits that this increase is insignificant in the case of non-leguminous plants. For potatoes (*Solanum tuberosum*) he found an increase from 0.022 to 0.2186 gram (about tenfold) in case no fixed nitrogen was present in the soil. White mustard showed an increase from 0.0012 to 0.0043 gram, or about 3½ fold, in the absence of fixed nitrogen, as compared with 350 fold when nitrogen was present in the soil.

Frank does not publish his method in detail, but mentions the fact that, in most cases at least, his cultures were not sterilized. In such cases the fixation of nitrogen was probably due to microörganisms.

In the experiments reported in this bulletin it will appear that the

*After this was written, Frank's article appeared in *Botanische Zeitung*, 1893, where he says (p. 153) that the plants, with the exception of the *Leguminosæ*, need nitrates during their young stage, and only afterwards are able to assimilate free nitrogen.

black and white mustards do not assimilate free nitrogen in the absence of fixed nitrogen, and that therefore Frank is wrong in claiming that these plants do assimilate perceptible quantities of free nitrogen, even when nitrates are not present in the soil.

As the trustworthiness of the results of investigations in this line

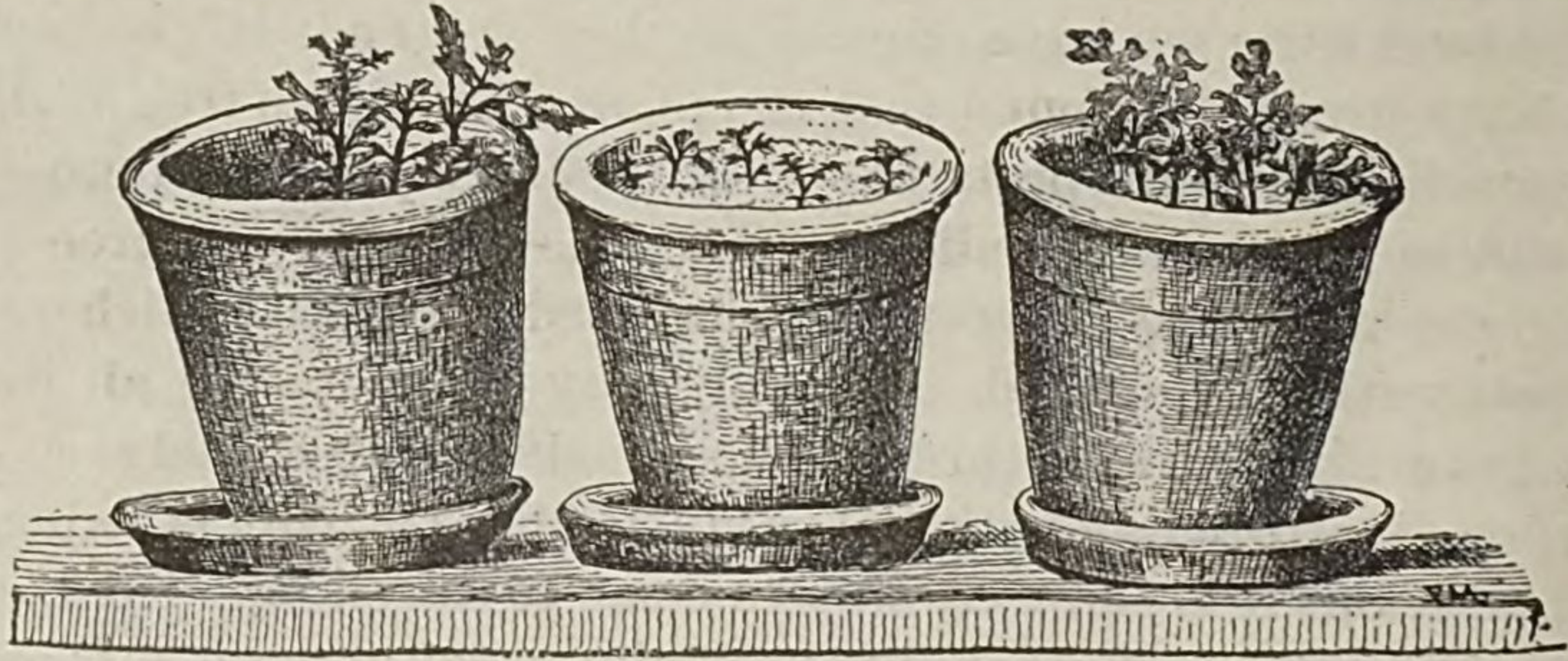


FIG. 1.—Sand cultures of *Sinapis alba*, July 31, with nitrates.

depends entirely on the method employed, the experiments here reported will be described in detail.

For the experiment eight rows of cultures were used. The first row contained 6 sand cultures, 3 with white and 3 with black mustard, which received nitrates as a fertilizer. The second row also contained



FIG. 2.—Sand cultures of *Sinapis alba*, Aug. 30, with nitrates.

6 sand cultures, 3 with white and 3 with black mustard, treated in every respect like the first row, except that they received no nitrates. The third row contained 6 water cultures, 3 of white and 3 of black mustard, which received nitrates. The fourth row was the same as the third, except that no nitrates were used. These four rows were not

sterilized, so that microörganisms were allowed to develop. The fifth row contained 4 sand cultures, 2 with white and 2 with black mustard, which were treated like those in the first row, except that they were sterilized. The sixth row contained 4 sand cultures like those of the second row, but sterilized. The seventh row contained 4 water cultures like those in the third row, but sterilized. The eighth row was

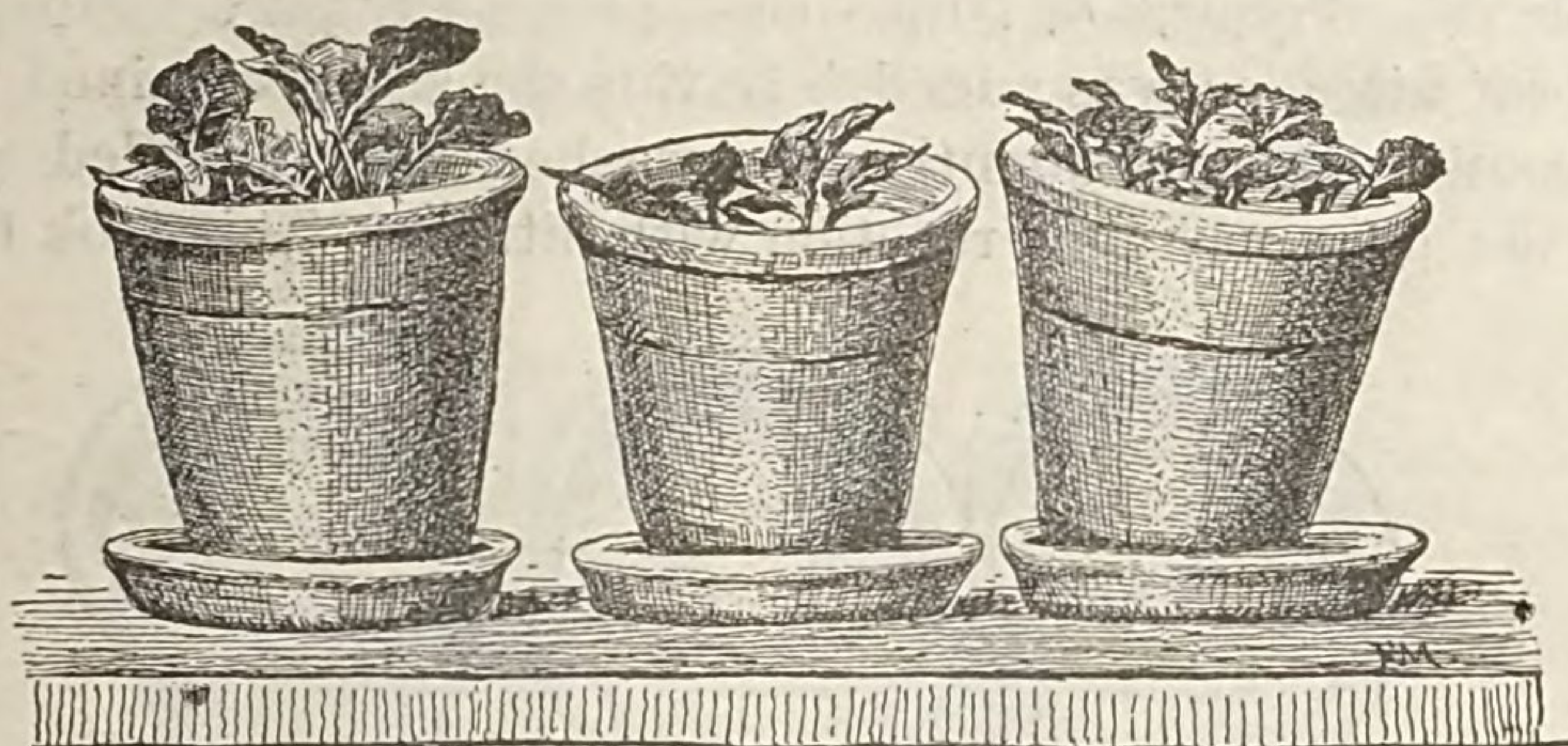


FIG. 3.—Sand cultures of *Sinapis nigra*, July 31, with nitrates.

identical with the fourth row except that the cultures were sterilized. In the last four rows of cultures the action of microörganisms was excluded.

All chemicals used in the experiments were of the grade "Purissimum" and yet were first tested for the possible presence of nitrogen. The calcium sulphate which could not be obtained here in that grade

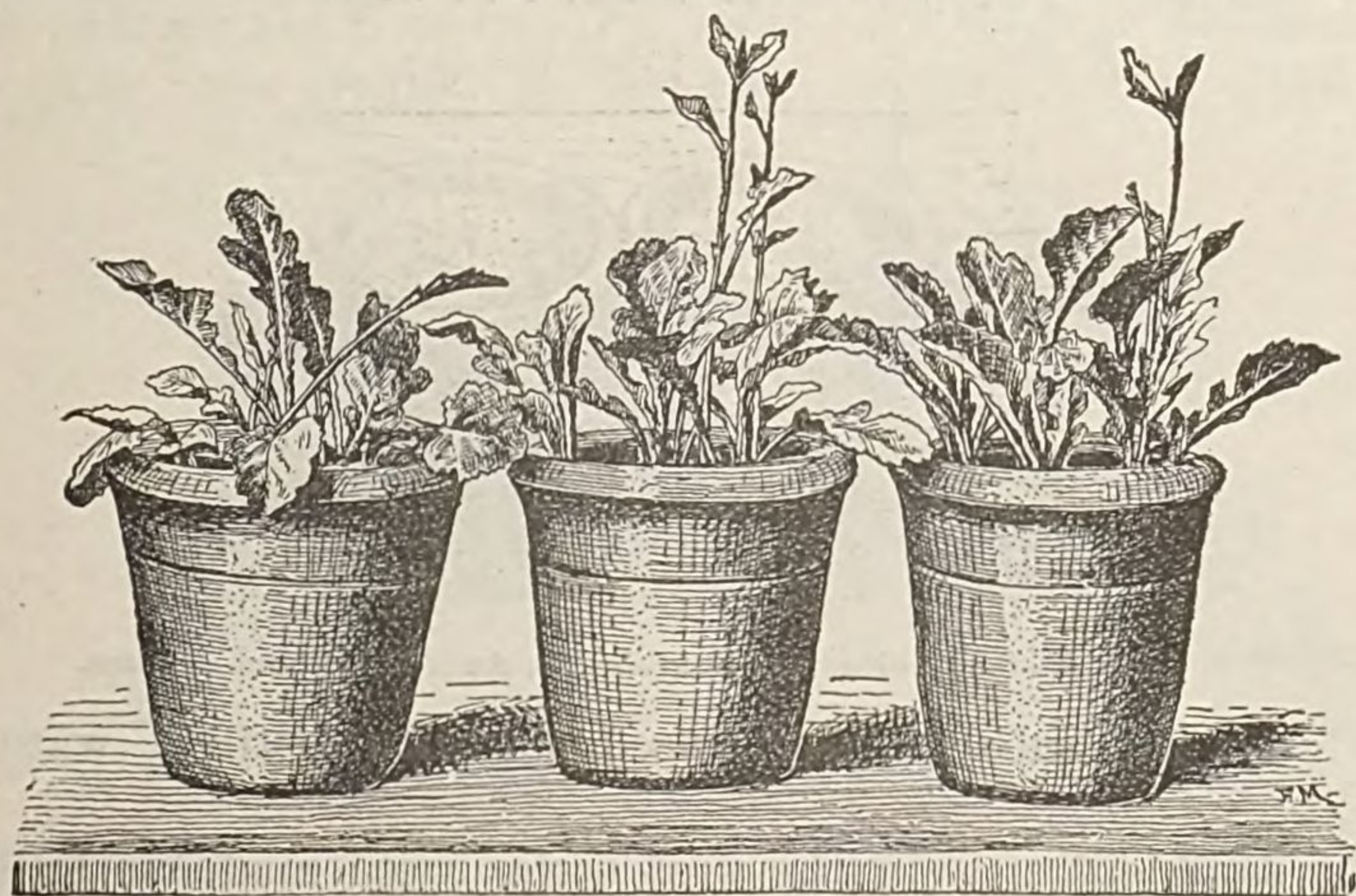


FIG. 4.—Sand cultures of *Sinapis nigra*, Aug. 30, with nitrates.

was imported from E. Merck, of Darmstadt, Germany. The water used for watering the plants as well as that for preparing the nutritive solutions, was redistilled until it failed to give the faintest blue coloration with diphenylamin or reddish coloration with Nessler's reagent. For the pots the finest sand obtainable in the neighborhood was used. This

was washed under a constant stream of hydrant water to eliminate all particles of clay and substances soluble in water, and this process was continued until the water, under constant stirring of the sand, ran away perfectly clear. Four quarts of sand were washed at a time and as the stream of hydrant water ran constantly for about three hours it was thoroughly cleansed.

After this, 3 quarts of 20 per cent chemically pure hydrochloric acid tested for nitrogen was added. In this the sand remained for twenty-four hours and subsequently was washed with distilled water until it did not give any acid reaction with litmus. This took for 4 quarts

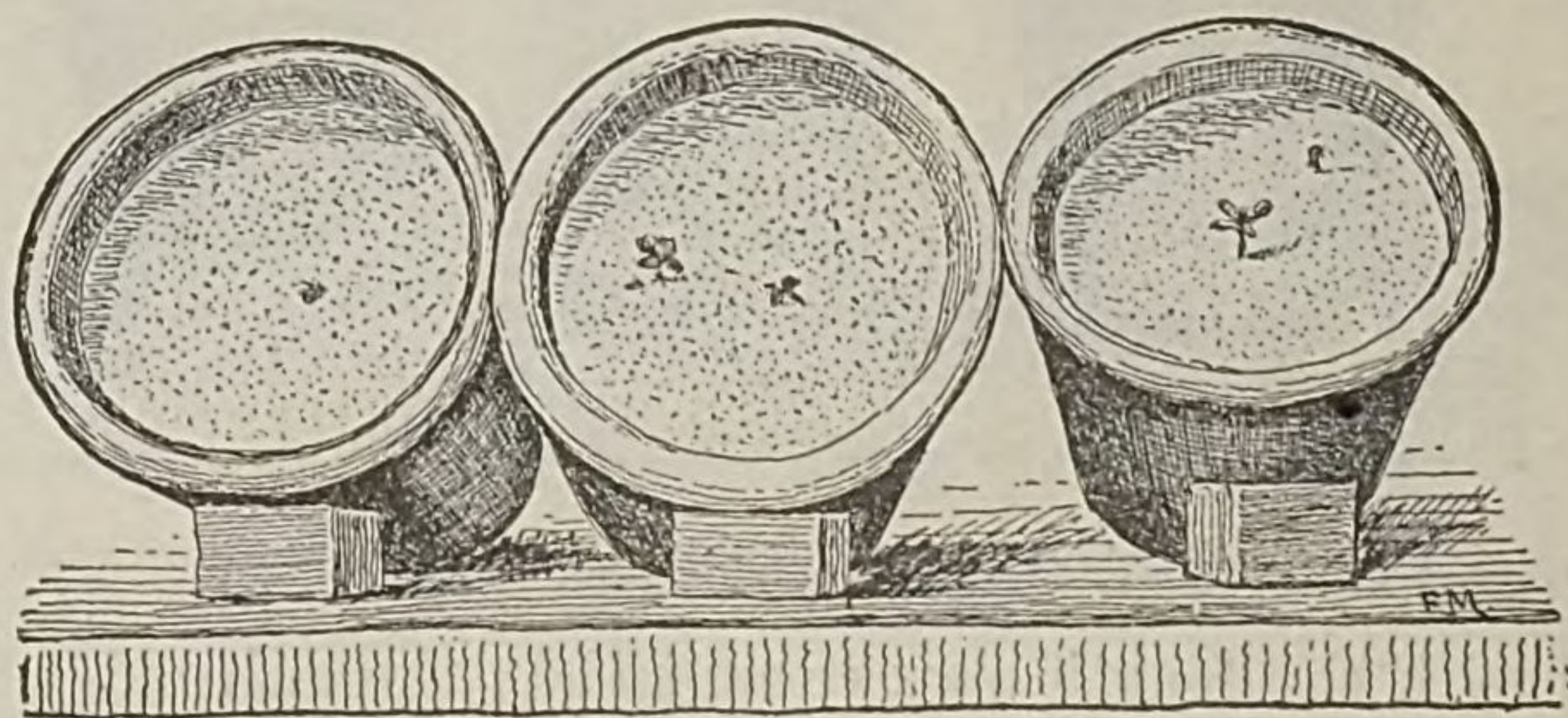


FIG. 5.—Sand cultures of *Sinapis alba*, July 31, without nitrates.

of sand about four or five hours and about 50 quarts of distilled water was used for the purpose. The sand was then dried in the air bath at a temperature of about 140° C., and afterwards ignited in a Hessian fire-proof crucible. The pots were soaked in distilled water for twenty-

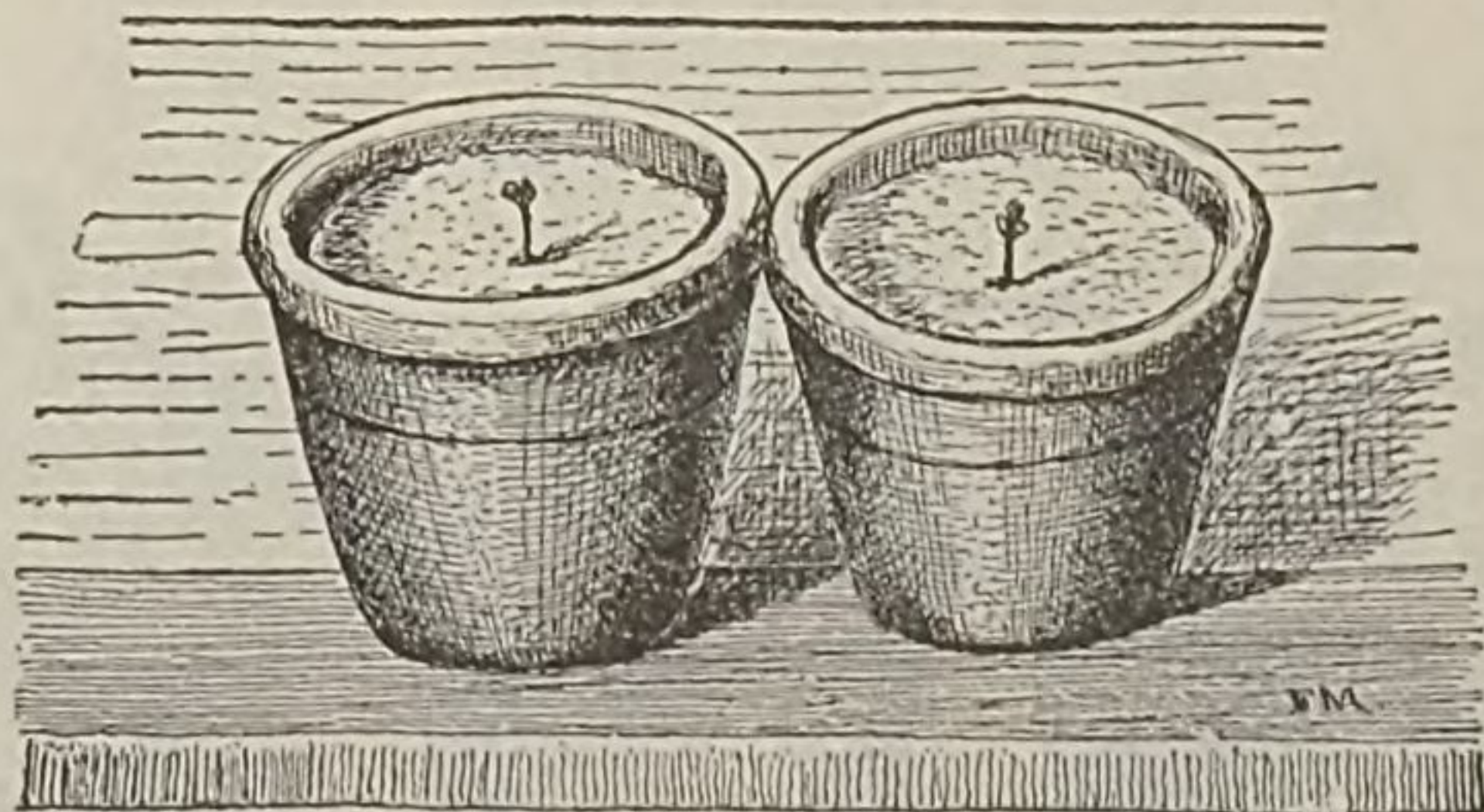


FIG. 6.—Sand cultures of *Sinapis alba*, Aug. 30, without nitrates.

four hours and subsequently rinsed out with distilled water several times.

The sand cultures in the first series were made as follows: The flower pots used were ordinary porous pots, each of which contained about $2\frac{1}{2}$ quarts of sand. This series was not sterilized and received the necessary fertilizer by watering with a nutritive solution containing 2 parts of nitrate of potassium, 1 part of chloride of sodium, 1 part of tricalcium phosphate, 1 part of calcium sulphate, 1 part of magnesium sulphate, and a few drops of chloride of iron. The concentration of the solution was 3:1,000 (0.3 per cent). In this way six pots were

treated. The seeds necessary for this experiment were sprouted in distilled water on filter paper. In each pot five seedlings a few days old were planted. In three pots (Figs. 1 and 2) *Sinapis alba* was planted, in the other three (Figs. 3 and 4) *S. nigra*. The plants were put in July 19, and were placed, in the absence of a hothouse, on the roof of the biological building of the university, where they were protected from too strong sunlight by screens of cheese cloth. The plants grew excellently, and throughout the experiment, which ended August 30, not a plant was lost. Pot 2 of *Sinapis alba* was blown

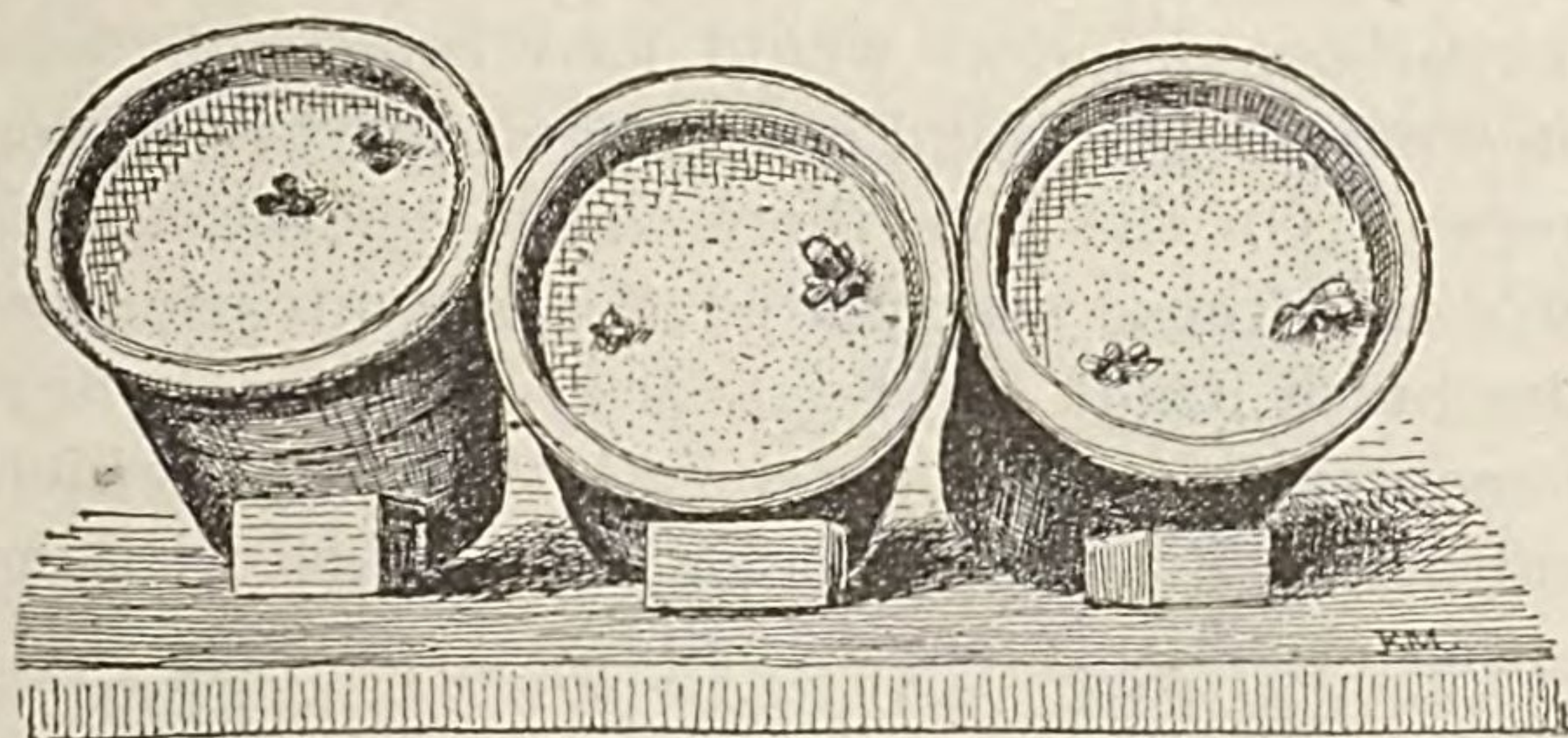


FIG. 7.—Sand cultures of *Sinapis nigra*, July 31, without nitrates.

over during a severe windstorm and had to be repotted, which of course kept the plants back in their development as seen in Fig. 1. This pot is not shown in the illustration taken at the end of the experiment, as the plants were yet backward in their development. All plants bore flowers, fruits, and seeds in abundance. Six other pots were treated in the same manner, except that the two

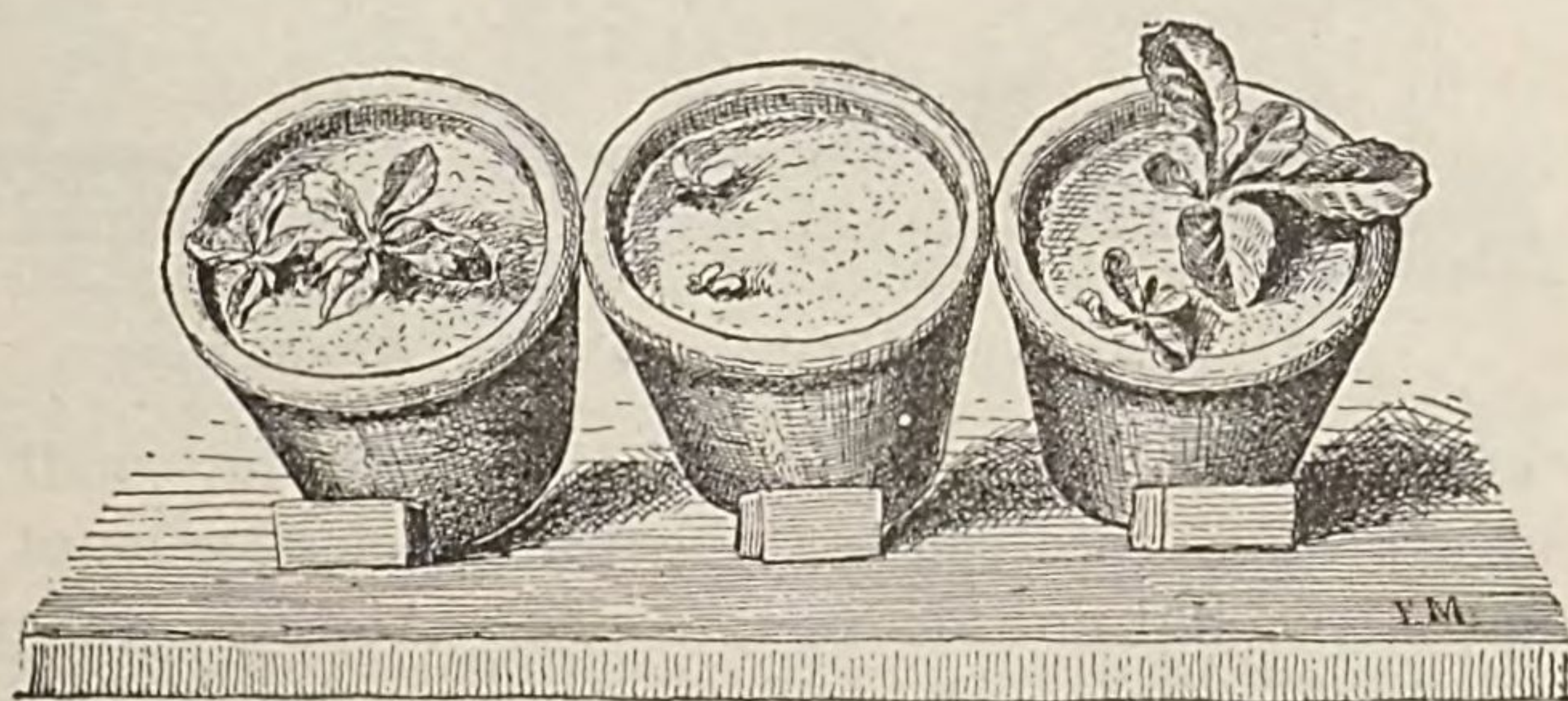


FIG. 8.—Sand cultures of *Sinapis nigra*, Aug. 30, without nitrates.

parts of nitrate of potassium were replaced by one part of chloride of potassium at the beginning of the experiment, and one part applied later on. Consequently these plants had no other nitrogen than the free nitrogen of the atmosphere. During rainy weather glass plates were put over the tops of the pots to keep them from receiving the traces of HNO_3 in the rain. As there was hardly any rain during the whole period of the experiment, there was practically no error from this cause. Of these pots, pot 1 containing *Sinapis alba*

showed July 31 (Fig. 5) but one very small and weak plant, pot 2 had two, and pot 3, one. August 30 (Fig. 6) pot 1 had one tiny plant, pot 2 none at all, and pot 3 only a very weak one. None of these plants, however, were larger than was to be expected considering the accumulated nitrogen present in the seed. In the case of *Sinapis nigra*, each of the three pots showed on July 31 (Fig. 7) two small plants. August 30 (Fig. 8) pots 1 and 3 had two unexpectedly large plants, considering the circumstances. Pot 2 had two small plants. None of these plants, however, had attained the size and vigor of those which received nitrates. We see here how necessary it is to make more than one series of experiments, for we would have concluded from this solitary series that *Sinapis nigra* could get along at least in a poor way without fixed nitrogen. On the pots there was a vegetation of algæ and it is just possible that these assimilated the free nitrogen, as indicated by the experiments of Frank and Schlösing. Beyerinck, however, was not able to demonstrate this property with those algæ which he could get in pure cultures. Frank and Schlösing worked with impure cultures in which other organisms may have played a role.

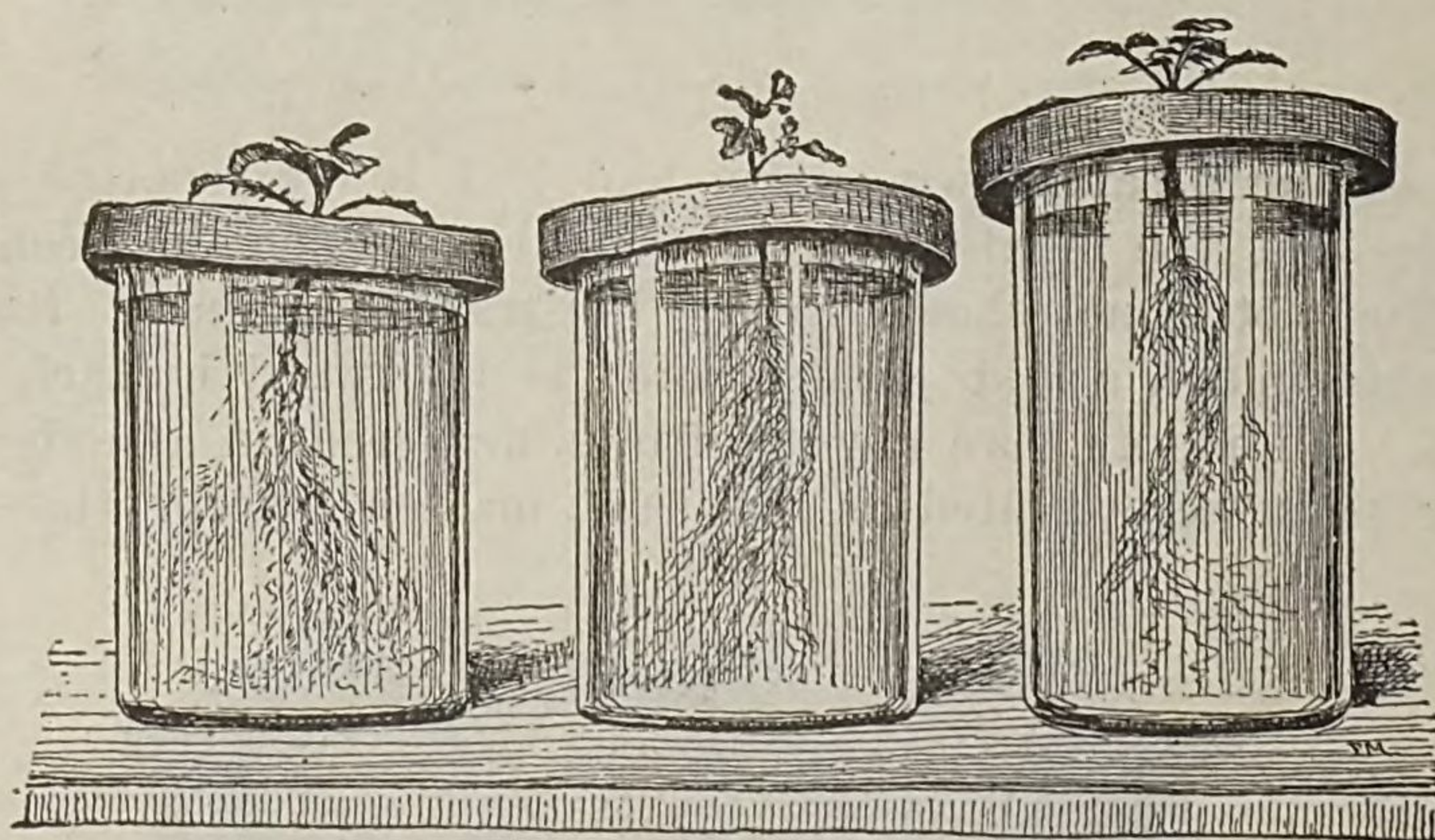


FIG. 9.—Water cultures of *Sinapis alba*, July 31, with nitrates.

It is also possible, but very improbable, that the small quantity of rain which the pots received contained a sufficient amount of nitrogen for *Sinapis nigra* but not for *Sinapis alba*. As there was a possibility that the soil might accumulate fixed nitrogen without the action of the mustard plants to every series of pots one pot was added which did not contain any plants at all, but which was treated in all respects exactly like those which did have plants. These pots also showed an accumulation of fixed nitrogen.

It was interesting to observe that the *Sinapis nigra* grew much better than *Sinapis alba*, notwithstanding all the plants were exposed to exactly the same influence, so that it would be well-nigh miraculous if the pots with *Sinapis nigra* had accumulated more nitrogen than those with *Sinapis alba*. We have therefore to conclude that *Sinapis nigra*

is able to live on less fixed nitrogen than *Sinapis alba*. This is remarkable in plants so closely allied and it might be of practical value to determine by exact experiments how different plants behave in this respect.

The illustrations are from drawings made from photographs by the author. All the photographs were taken at the same distance, and great pains taken to make the drawings of the same size as the photographs. The exact relations as to size, etc., which existed between the different plants are therefore shown in the illustrations.

To recapitulate: We see from the illustrations that the plants which received fixed nitrogen grew regularly from July 19 to August 30, after which date they formed seed. Those which received no fixed nitrogen grew

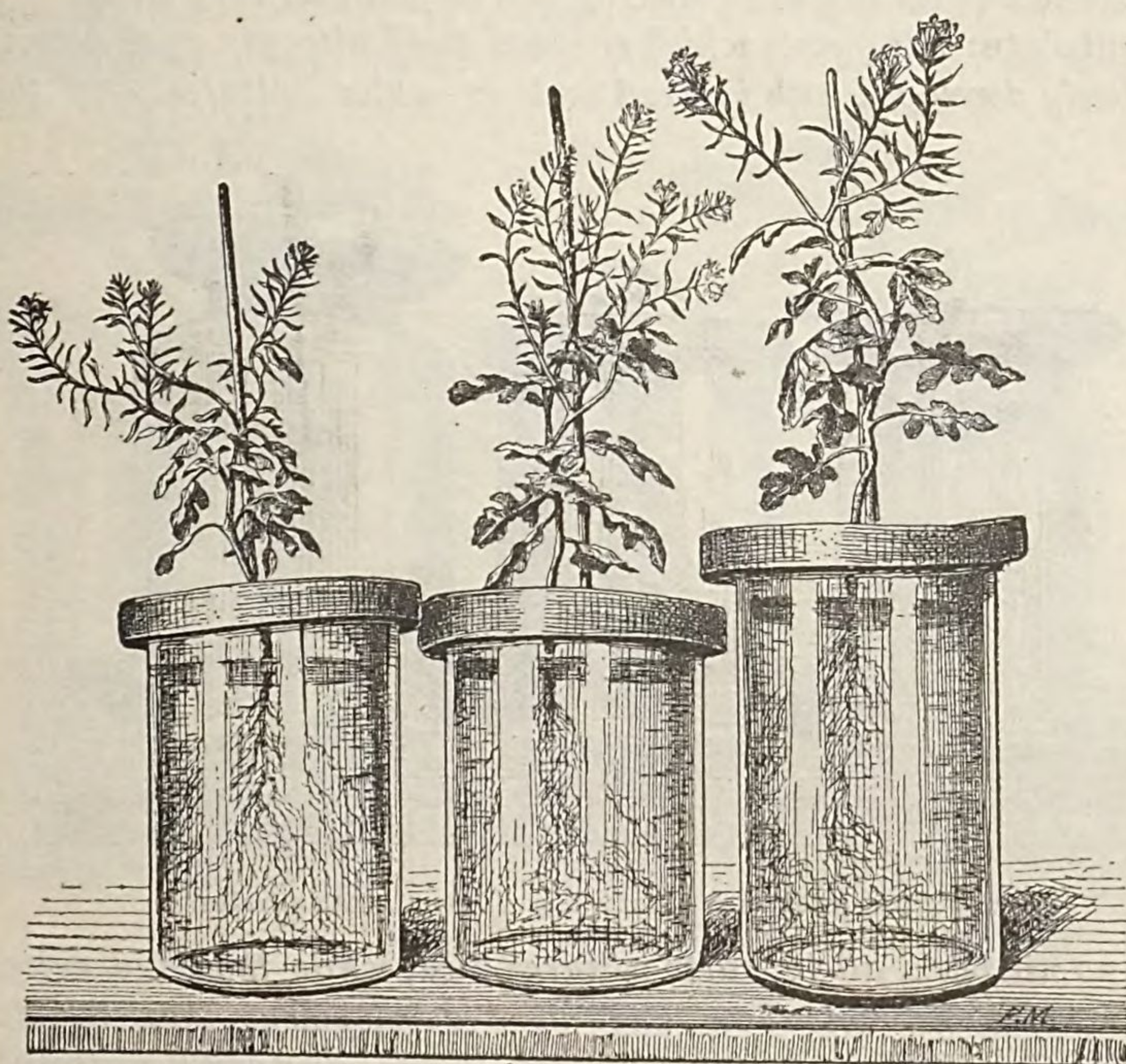


FIG. 10.—Water cultures of *Sinapis alba*, Aug. 30, with nitrates.

a little till July 31 and the combined quantity of produced organic matter was at the end of the experiment even a little less than on July 31, owing to the death of one of the plants caused by nitrogen hunger. It is noticeable, however, that the plants of black mustard which received no fixed nitrogen grew towards the end of the experiment considerably more than those of white mustard.

Now let us see how these plants behaved in water cultures. For this series six glass vessels were used which were scrupulously cleaned and afterwards filled with the same nutritive solutions as those which were used for sand cultures. The concentration was at first made 3 per cent and during the whole course of the experiment the used-up food

solution was replaced by distilled water until the original volume was reached. The vessels contained about 6 quarts and to every quart 3 drops of a concentrated aqueous solution of chloride of iron were added. The part of the culture vessel containing the roots was protected from the light by means of paper. On top of the vessel was placed a wooden cover with a round hole in the center in which the seedling was fixed by means of cotton. In three of the vessels *Sinapis alba* (Figs. 9 and 10) was planted and in the three others *Sinapis nigra* (Figs. 11 and 12). All these plants developed excellently.

Six other vessels were treated exactly in the same way, but in place of two parts of nitrate of potassium, one part of chloride of potassium, later on increased to two parts, was used. All these plants died before August 1 (Fig. 13), after having developed but very little.

To recapitulate: *All plants which received fixed nitrogen were normally and completely developed both in sand and in water cultures. Of those*

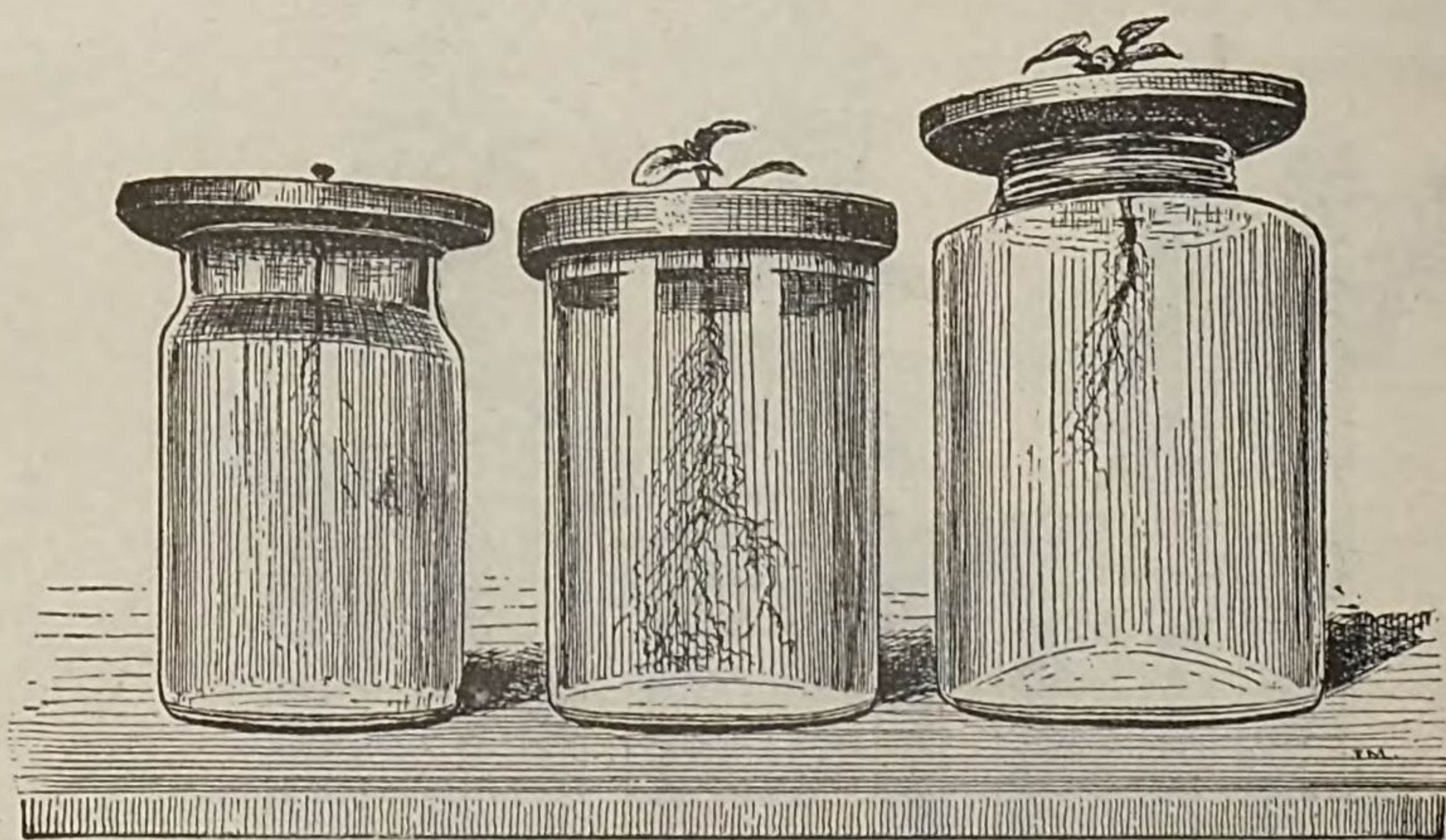


FIG. 11.—Water cultures of *Sinapis nigra*, July 31, with nitrates.

which got no nitrogen, all in water cultures died, while the sand cultures of Sinapis alba did not show any more development than could be explained by the nitrogen contained in the seed. The sand cultures of Sinapis nigra, however, developed so far as to indicate an assimilation of free nitrogen.

To find out whether the plants themselves were the cause of these phenomena or whether other influences, *e. g.*, the action of microorganisms, played a role here, a series of sterilized sand and water cultures were made.

The sterilized sand cultures were prepared as follows: The pots were glazed on the outside and the hole in the bottom was plugged up with cotton. They were then filled with the prepared sand. Subsequently a powder containing 3 grams either of the complete nutritive material or of the one in which the nitrate of potassium was replaced by the chloride was added to every pot. These powders had previously been

sterilized by exposing them in glass vessels for five hours to a dry heat at a temperature of $140^{\circ}\text{C}.$, every 3 grams being separately wrapped up in paper. After this the top of the pot was closed by tying over it a double sheet of cotton. The pots were then placed in the dry sterilizer together with the following articles: (1) One glass vessel about 50 cm. high, the bottom of which was thickly covered with cotton and the opening at the top closed by a double sheet of cotton tied over it; (2) a long straight glass tube, plugged at both ends with cotton; (3) two small U-shaped glass tubes with cotton plugged openings; (4) a glass bottle closed with a rubber stopper with two openings and covered with a double sheet of cotton. All these were exposed during five hours to a temperature of $140^{\circ}\text{C}.$ After cooling, the pot was placed

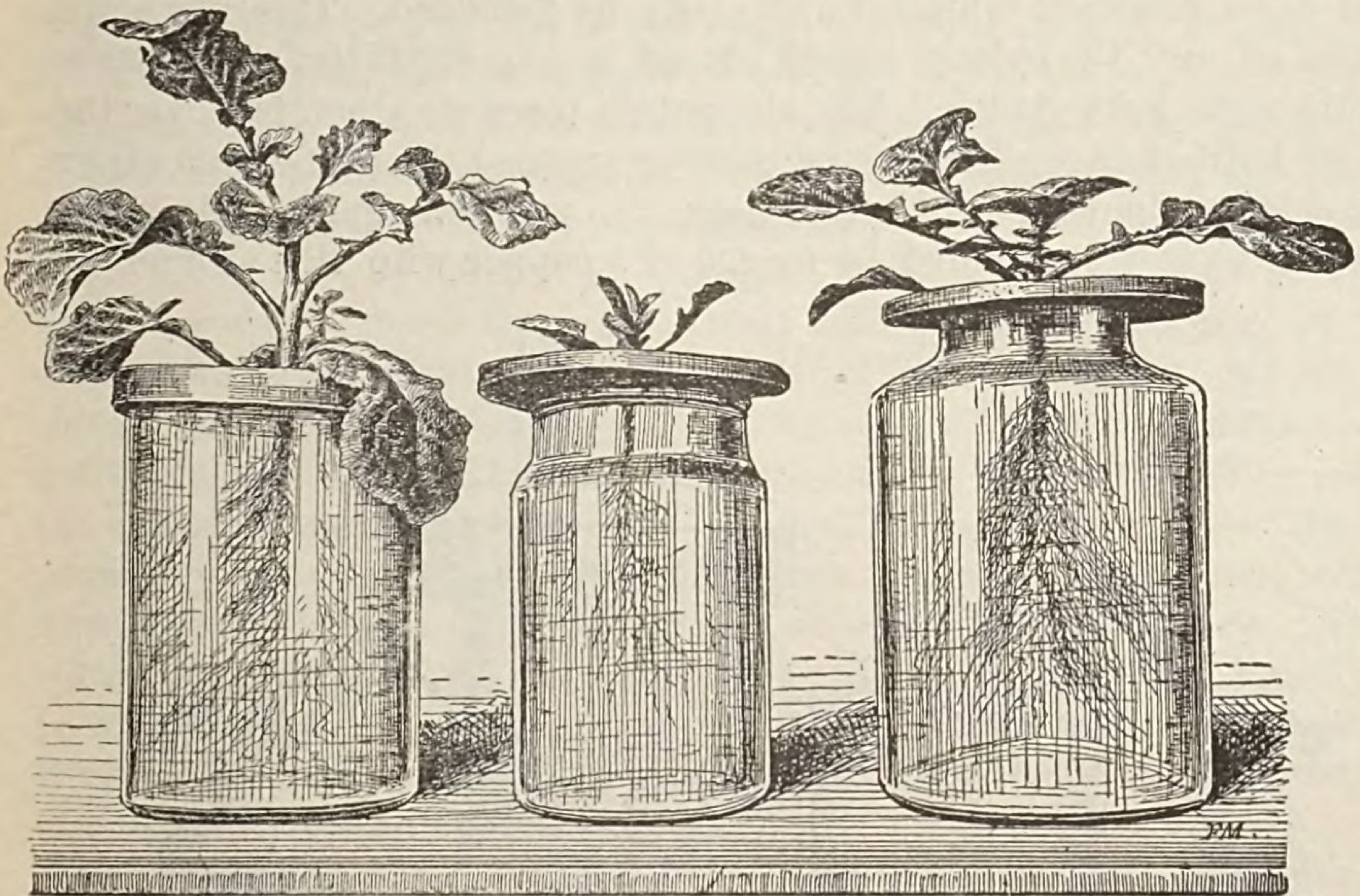


FIG. 12.—Water cultures of *Sinapis nigra*, Aug. 30, with nitrates.

inside of the glass vessel on the cotton, which held it firmly in position. The cotton tied over the top of the pot was taken away and the top of the glass vessel was again closed with a double sheet of sterilized cotton. In this a small hole was made through which the long tube was inserted, so that its lower end rested on the sand in the pot while the upper end extended about 1 cm. outside of the vessel above the cotton. Over all a piece of parchment paper was tied with a hole in it for the tube and where this was too big it was again closed by means of a little wadding. Distilled water was put in the bottle and the two small glass tubes were put in the stopper after the manner of a wash bottle. In one end of the shorter tube a little plug of cotton remained. The tube which reached the water was now united with the tube in the glass vessel by means of a rubber tube. Finally cotton was tied around the stopper of the water bottle and also around the places where the

rubber tubing fitted around the glass tubes. The whole apparatus put together in the manner described was now sterilized in the steam sterilizer on three consecutive days for three quarters of an hour each day. For this an ordinary steam sterilizer was used to which an elongation



FIG. 13.—Water cultures of *Sinapis alba* and *S. nigra*, July 31, without nitrates.

had been attached which could easily be detached. This piece was taken off and the culture vessel placed in the sterilizer, an assistant holding the water bottle. The elongation piece was then put over the water bottle and while the experimenter grasped the bottle from above the assistant put the elongation piece into position again. The water bottle was now suspended by means of a copper wire tied around its

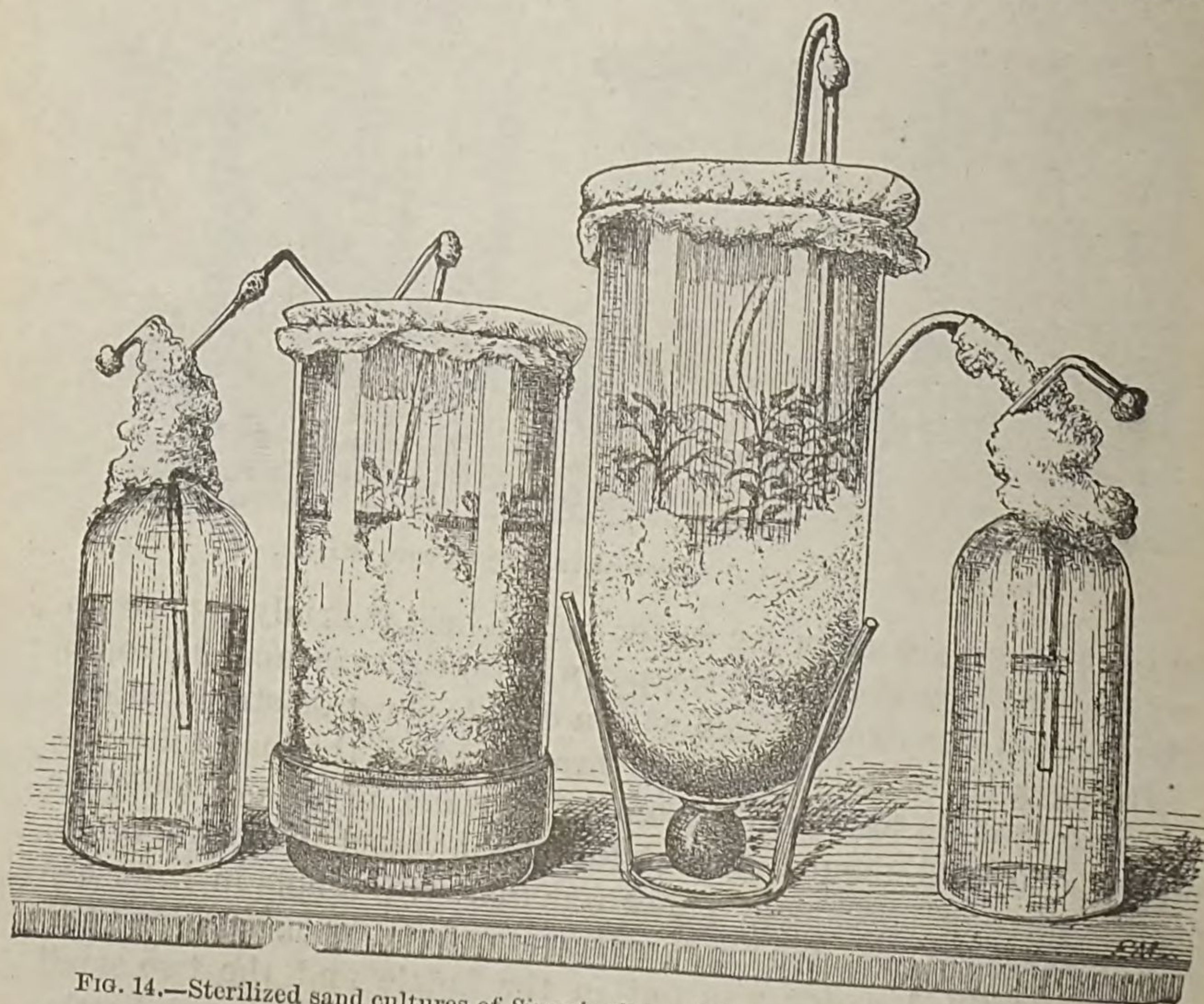


FIG. 14.—Sterilized sand cultures of *Sinapis alba* and *S. nigra*, August 30, with nitrates.

neck and fixed to the upper border of the elongation piece. Subsequently the top was put on and sterilization allowed to take place. The arrangement of the culture is shown in Fig. 14.

The seeds used in these experiments were first washed with corrosive sublimate of a concentration of 1:1,000. This had to be done quite

rapidly, as it was found that the seeds were easily killed by the action of the sublimate. After that they were exposed, inclosed in sterilized petri-dishes during two days, to very strong sunlight to kill the bacteria as far as possible. The layer of seeds was only one thick and they were shaken from time to time to expose all sides equally. During the preliminary experiments it was found that even without the previous washing in sublimate the germinating power was very much decreased by the action of the sunlight, so that seeds apparently behave under such conditions like spores of bacteria. It is not positive that all bacteria were killed by the process, but it was impossible to do more. It was noted that the sprouting seeds treated in this way were never accompanied by fungi as were those which were not treated. It would perhaps be possible to get seeds entirely free from bacteria by cutting them out of the unopened ovary. After having been thus exposed to the action of the sun the seeds were taken from the petri-dishes with sterilized forceps and allowed to sprout on sterilized wet sand in sterilized glass boxes. After they were well sprouted they were taken out by means of sterilized forceps and planted in the following way: Above the glass vessel containing the pot was hung a large inverted glass funnel, the tube of which was plugged with cotton and the inner side wiped out by means of a towel soaked in corrosive sublimate. This served to prevent bacteria from falling into the culture vessel after lifting the parchment paper and cotton. Subsequently the right hand and bare arm of the experimenter were scrubbed with soap and water and washed with sublimate. The cotton parchment cover was lifted just enough to allow the hand to pass through it and the seedlings were planted with sterilized forceps. Five seedlings were planted in each pot. After this all the apparatus was carefully closed again.

By lifting the water bottle and turning it upside down it was now possible to water the plants without danger of contamination. An objection to cultures like this is that the plants are growing in an atmosphere which is very rich in watery vapor, but it is not feasible to avoid this difficulty. Through lack of a sufficient number of large glass vessels only four cultures could be made, two with and two without fixed nitrogen. Five plants of *Sinapis alba* and five of *Sinapis nigra* were planted in each series.

The experiments were begun August 9 and closed August 30, before the plants bloomed. In the cultures which received nitrates both *Sinapis alba* and *Sinapis nigra* developed finely. Though no further attention was paid to them, by September 25 the plants had grown up so as to reach the tops of the vessel and were in bud. At this time the plants were destroyed. According to Frank's experiments it would be impossible to get them to open their buds in such an atmosphere. Those plants which got no nitrates died very soon after planting.

The following apparatus was used in the sterilized water cultures (Fig. 15): Six glass vessels, the openings of which were tied with cotton; six bell glasses, with openings at both sides, both closed with cotton; six straight glass tubes, cotton plugged at both ends; six washing bottles, with cotton tied around the stopper and tubes plugged with cotton, and six corks with holes in the center inclosed in a cotton-plugged glass cylinder. These articles were sterilized during five hours dry at a temperature of 140°C .

Subsequently, the washing bottles were filled with sterilized distilled water; three of the vessels were filled with sterilized nutritive

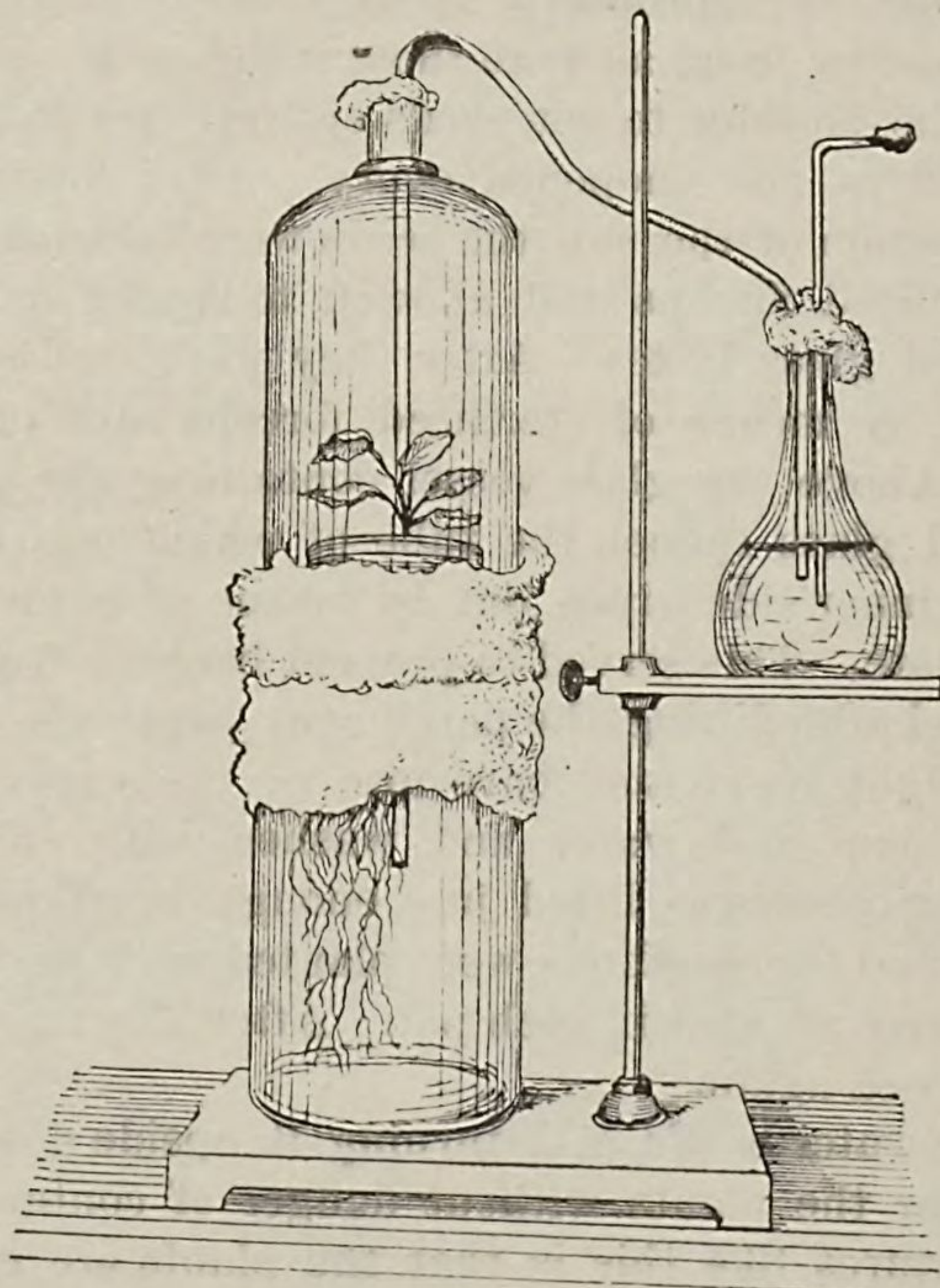


FIG. 15.—Sterilized water culture of *Sinapis nigra*, August 30, with nitrates.

solutions containing nitrates, and the three others with similar solutions, in which the nitrate was replaced by chloride of potassium.

After this cotton was wound around the mouth of the glass vessels and bell jars placed above the glass vessels in such a way that the joints were tightly closed by the cotton, the remaining openings being plugged with cotton. Around the joints, between the glass vessels and bell jars, a sheet of cotton was wound and tied above and below the rim of the bell jar. The glass tube was introduced into the food solution through the upper opening of the bell glass, the cotton plug was replaced, and the end of the tube projecting from the bell jar was united with the tube which reached the water in the wash bottle by means of a rubber tube. Cotton was tied around the places where the

rubber touched glass. The whole apparatus, put together in this way, was sterilized in the manner described for the sand cultures. The seeds were prepared in the same way as those for the sand cultures. The seedlings were fixed by means of sterilized cotton in the corks which just before were passed through the flame. By lifting the bell glass a little it was now possible to put corks and plants into the culture vessel and let them float on the food solution. After having replaced the outer sheet of cotton a piece of paper was tied around the under half of the apparatus to prevent the light from doing harm to the root system of the plant. Four of the vessels were filled with food solutions free of nitrates and two received nitrates. The two plants in the food solution with nitrates grew very well (see Fig. 15), the four without nitrates died.

The conclusion to which these experiments lead us is this: *Neither of the two mustard species, Sinapis alba and S. nigra, is able to live without fixed nitrogen.*

U. S. DEPARTMENT OF AGRICULTURE
OFFICE OF EXPERIMENT STATIONS

BULLETIN No. 19

ORGANIZATION LISTS
OF THE
AGRICULTURAL EXPERIMENT STATIONS
AND
AGRICULTURAL SCHOOLS AND COLLEGES
IN THE
UNITED STATES

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

JANUARY, 1894.

WASHINGTON
GOVERNMENT PRINTING OFFICE
1894

OFFICE OF EXPERIMENT STATIONS.

A. C. TRUE, Director.

E. W. ALLEN, Assistant Director and Editor of departments of Chemistry, Foods and Animal Production, and Dairying.

W. H. BEAL, Editor of departments of Meteorology, Fertilizers, Soils, and Indexes.

WALTER H. EVANS, Editor of departments of Botany, Seeds, Weeds, and Diseases of Plants.

J. F. DUGGAR, Editor of departments of Field Crops and Veterinary Science and Practice.

W. O. ATWATER, Special Agent.

F. W. WOLL, Special Agent.

F. H. HALL, Librarian.

S. L. SOMMERS, Record Clerk.

THE AGRICULTURAL EXPERIMENT STATIONS.

ALABAMA—*Auburn*: College Station; W. L. Brown.† *Uniontown*: Canebrake Station; H. Benton.‡

ARIZONA—*Tucson*: F. A. Gulley.*

ARKANSAS—*Fayetteville*: R. L. Bennett.*

CALIFORNIA—*Berkeley*: E. W. Hilgard.*

COLORADO—*Fort Collins*: Alston Ellis.*

CONNECTICUT—*New Haven*: State Station; S. W. Johnson.* *Storrs*: Storrs Station; W. O. Atwater.*

DELAWARE—*Newark*: A. T. Neale.*

FLORIDA—*Lake City*: O. Clute.*

GEORGIA—*Experiment*: R. J. Redding.*

IDAHO—*Moscow*: C. P. Fox.*

ILLINOIS—*Champaign*: G. E. Morrow.†

INDIANA—*La Fayette*: C. S. Plumb.*

IOWA—*Ames*: James Wilson.*

KANSAS—*Manhattan*: G. T. Fairchild.‡

KENTUCKY—*Lexington*: M. A. Scovell.*

LOUISIANA—*Audubon Park, New Orleans*: Sugar Station. *Baton Rouge*: State Station. *Calhoun*: North Louisiana Station. W. C. Stubbs.*

MAINE—*Orono*: W. H. Jordan.*

MARYLAND—*College Park*: R. H. Miller.*

MASSACHUSETTS—*Amherst*: State Station; C. A. Goessmann.* *Amherst*: Hatch Station; H. H. Goodell.*

MICHIGAN—*Agricultural College*: L. G. Gorton.*

MINNESOTA—*St. Anthony Park*: W. M. Liggett.‡

MISSISSIPPI—*Agricultural College*: S. M. Tracy.*

MISSOURI—*Columbia*: E. D. Porter.*

MONTANA—*Bozeman*: S. M. Emery.*

NEBRASKA—*Lincoln*: C. L. Ingersoll.*

NEVADA—*Reno*: S. A. Jones.*

NEW HAMPSHIRE—*Durham*: G. H. Witcher.*

NEW JERSEY—*New Brunswick*: State Station; E. B. Voorhees.* *New Brunswick*: College Station; A. Scott.*

NEW MEXICO—*Las Cruces*: H. Hadley.*

NEW YORK—*Geneva*: State Station; P. Collier.* *Ithaca*: Cornell University Station; I. P. Roberts.*

NORTH CAROLINA—*Raleigh*: H. B. Battle.*

NORTH DAKOTA—*Fargo*: J. B. Power.*

OHIO—*Wooster*: C. E. Thorne.*

OKLAHOMA—*Stillwater*: J. C. Neal.*

OREGON—*Corvallis*: J. M. Bloss.*

PENNSYLVANIA—*State College*: H. P. Armsby.*

RHODE ISLAND—*Kingston*: C. O. Flagg.*

SOUTH CAROLINA—*Clemson College*: E. B. Craighead.*

SOUTH DAKOTA—*Brookings*: L. McLouth.‡

TENNESSEE—*Knoxville*: C. F. Vanderford.**

TEXAS—*College Station*: J. H. Connell.*

UTAH—*Logan*: J. W. Sanborn.*

VERMONT—*Burlington*: J. L. Hills.*

VIRGINIA—*Blacksburg*: J. M. McBryde.*

WASHINGTON—*Pullman*: E. A. Bryan.*

WEST VIRGINIA—*Morgantown*: J. A. Myers.*

WISCONSIN—*Madison*: W. A. Henry.*

WYOMING—*Laramie*: A. A. Johnson.*

* Director.

† President of board of direction.

‡ Assistant director in charge.

§ Chairman of council.

** Secretary.

TABLE OF CONTENTS.

	Page.
Letter of transmittal	7
List of abbreviations	8
List of experiment stations in the United States, with governing boards and station staffs.....	9
List of agricultural schools and colleges in the United States, with courses of study and boards of instruction	29
Officers of the Association of American Agricultural Colleges and Experiment Stations	59
Officers and reporters of the Association of Official Agricultural Chemists of the United States.....	60
List of station publications received during 1892 and 1893	61
Federal legislation affecting agricultural colleges and experiment stations...	74
Regulations of the Post-Office Department regarding experiment station publications	80
Rulings of the Treasury Department as to the construction of the act of Congress of March 2, 1887, establishing agricultural experiment stations	81
Index of names	85

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., January 12, 1894.

SIR: I have the honor to transmit herewith, for publication, Bulletin
No. 19 of this Office.

Respectfully,

A. C. TRUE,
Director.

Hon. J. STERLING MORTON,
Secretary of Agriculture.

LIST OF ABBREVIATIONS.

<i>Agr.</i> , Agriculture, Agriculturist, Agricultural.	<i>Lab.</i> , Laboratory.
<i>Anal.</i> , Analytical.	<i>Lib.</i> , Librarian.
<i>Arbor.</i> , Arboriculture, Arboriculturist.	<i>Math.</i> , Mathematics.
<i>Assoc.</i> , Associate.	<i>Mech.</i> , Mechanics, Mechanical.
<i>Asst.</i> , Assistant.	<i>Met.</i> , Meteorology, Meteorologist.
<i>Bact.</i> , Bacteriology, Bacteriologist.	<i>Min.</i> , Mineralogy, Mineralogist.
<i>Biol.</i> , Biology, Biologist, Biological.	<i>Myc.</i> , Mycologist.
<i>Bot.</i> , Botany, Botanist, Botanical.	<i>Physiol.</i> , Physiology, Physiological, Physiologist.
<i>Chem.</i> , Chemist, Chemistry, Chemical.	<i>Polit.</i> , Political.
<i>Chair.</i> , Chairman.	<i>Pres.</i> , President.
<i>Dept.</i> , Department.	<i>Prin.</i> , Principal.
<i>Dir.</i> , Director.	<i>Sec.</i> , Secretary.
<i>Elect.</i> , Electrical, Electricity.	<i>Sta.</i> , Station.
<i>Engin.</i> , Engineer, Engineering.	<i>Sten.</i> , Stenographer, Stenography.
<i>Ent.</i> , Entomology, Entomologist.	<i>Supt.</i> , Superintendent.
<i>Expt.</i> , Experiment.	<i>Treas.</i> , Treasurer.
<i>Geol.</i> , Geology, Geologist, Geological.	<i>Univ.</i> , University.
<i>Gov.</i> , Governor.	<i>V. Dir.</i> , Vice Director.
<i>Hort.</i> , Horticulture, Horticulturist.	<i>Vet.</i> , Veterinary, Veterinarian.
<i>Instr.</i> , Instructor.	<i>Vit.</i> , Viticulture, Viticulturist.
<i>Irrig.</i> , Irrigation.	<i>Zoöl.</i> , Zoölogy, Zoölogist.

LIST OF EXPERIMENT STATIONS IN THE UNITED STATES, WITH GOV-
ERNING BOARDS AND STATION STAFFS.

ALABAMA.

**Agricultural Experiment Station of the Agricultural and Mechanical College
of Alabama, Auburn.**

Department of the Agricultural and Mechanical College of Alabama.

GOVERNING BOARD.

J. G. Gilchrist (*Pres.*), *Hope Hull*; R. F. Ligon, *Tuskegee*; H. C. Armstrong, *Auburn*.

STATION STAFF.

W. L. Broun, M. A., LL. D., <i>President of the College and of Board of Direction.</i>	
B. B. Ross, M. S., <i>Chem.</i>	J. T. Anderson, Ph. D., <i>1st Asst. Chem.</i>
P. H. Mell, M. E., Ph. D., <i>Bot. and Met.</i>	R. E. Noble, M. S., <i>2d Asst. Chem.</i>
A. J. Bondurant, <i>Agr. and Biol.</i>	C. L. Hare, M. S., <i>3d Asst. Chem.</i>
C. A. Cary, D. V. M., <i>Vet.</i>	R. L. Bivins, B. Sc., <i>Clerk and Asst. Bot.</i>

Canebrake Agricultural Experiment Station, Uniontown.

GOVERNING BOARD.

H. D. Lane (*Pres.*), *Montgomery*; H. Benton (*Sec.*), *Uniontown*; M. Walker, (*Treas.*) *Faunsdale*; W. L. Broun, *Auburn*; W. M. Booker, *Uniontown*; J. Huggins, *Newbern*; A. Sledge, *Whitsett*; G. D. Stollenwerck, *Tombigbee*.

STATION STAFF.

W. L. Broun, M. A., LL. D., <i>Dir.</i>	J. A. Stuart, V. M. D., <i>Vet.</i>
H. Benton, M. S., <i>Asst. Dir. in Charge.</i>	M. Walker, <i>Treas.</i>

ARIZONA.

Agricultural Experiment Station of the University of Arizona, Tucson.

Department of the University of Arizona.

GOVERNING BOARD.

Rochester Ford (*Pres.*), *Tucson*; M. P. Freeman (*Sec.*), *Tucson*; Selim M. Franklin (*Treas.*), *Tucson*; Herbert Tenney, *Tucson*; Chas. M. Bruce, *Phoenix*; F. J. Nether-
ton, *Mesa City*.

STATION STAFF.

T. B. Comstock, D. Sc., <i>President of the University.</i>	
Frank A. Gulley, M. S., <i>Dir.</i>	James W. Toumey, B. S., <i>Bot. and Ent.</i>
Chas. B. Collingwood, M. S., <i>Chem. and</i>	Mark Walker, <i>Asst. Hort.</i>
<i>Met.</i>	Joseph A. Heberly, <i>Asst. Chem.</i>
Edward M. Boggs, C. E., <i>Irrig. Engin.</i>	R. J. Ferguson, <i>Engin.</i>
M. Moss, <i>Foreman Substa., Phoenix.</i>	

ARKANSAS.

Arkansas Agricultural Experiment Station, Fayetteville.

Department of Arkansas Industrial University.

GOVERNING BOARD.

J. T. Henderson (*Pres.*), *Auvergne*; S. E. Marrs (*Sec.*), *Fayetteville*; W. H. Langford, *Pine Bluff*; B. C. Black, *Searcy*.

STATION STAFF.

E. H. Murfee, LL. D., <i>President of the University.</i>	
R. L. Bennett, B. S., <i>Dir. and Agr.</i>	Geo. B. Irby, B. A., <i>Asst. Agr. Substa.,</i>
Geo. L. Teller, M. S., <i>Chem.</i>	<i>Newport.</i>
R. R. Dinwiddie, V. S., <i>Vet.</i>	C. L. Newman, B. S., <i>Asst. Agr. Substa.,</i>
J. T. Stinson, B. S., <i>Hort.</i>	<i>Camden.</i>
J. F. Moore, <i>Asst. Chem. and Lib.</i>	

CALIFORNIA.

Agricultural Experiment Station of the University of California, *Berkeley.*

Department of the University of California.

GOVERNING BOARD.

Gov. H. H. Markham (*Pres.*), *Sacramento*; J. H. C. Bonté (*Sec.*), *Berkeley*; Louis Sloss (*Treas.*), *310 Sansome St., San Francisco*; J. B. Reddick, *San Andreas*; F. H. Gould, *Stockton*; J. W. Anderson, *Sacramento*; Jno. Boggs, *Princeton*; Andrew S. Hallidie, *9 Fremont St., San Francisco*; Jas. A. Waymire, *Alameda*; Horatio Stebbins, *1609 Larkin St., San Francisco*; Chester Rowell, *Fresno*; T. G. Phelps, *Belmont*; Columbus Bartlett, *206 Sansome St., San Francisco*; G. T. Marye, jr., *234 Montgomery St., San Francisco*; J. West Martin, *Union Savings Bank, Oakland*; G. J. Ainsworth, *Redondo*; H. S. Foote, *Mills Building, San Francisco*; I. W. Hellman, *Nevada Bank, San Francisco*; W. T. Wallace, *799 Van Ness Ave., San Francisco*; C. F. Crocker, *Cor. Fourth and Townsend Sts., San Francisco*; J. F. Houghton, *303 California St., San Francisco*; Arthur Rodgers, *309 Montgomery St., San Francisco*; Albert Miller, *Cor. California and Sansome Sts., San Francisco*.

STATION STAFF.

Martin Kellogg, M. A., LL. D., <i>President of the University.</i>	
E. W. Hilgard, PH. D., LL. D., <i>Dir., Geol., and Chem.</i>	A. P. Hayne, PH. B., <i>Asst. in Charge of Viticulture and Olive Culture.</i>
E. J. Wickson, M. A., <i>Supt. Agr. Grounds.</i>	Geo. E. Colby, PH. B., <i>Asst. Chem. Viti-cultural Lab.</i>
E. L. Greene, PH. B., <i>Bot.</i>	
R. H. Loughridge, PH. D., <i>Agr. Geol. and Agr. Chem.</i>	C. H. Shinn, B. A., <i>Inspector Stations.</i>
	Emil Kellner, <i>Foreman Grounds.</i>
C. W. Woodworth, M. S., <i>Ent.</i>	F. T. Bioletti, <i>Foreman Cellar.</i>
M. E. Jaffa, PH. B., <i>Asst. in Agr. Lab.</i>	A. V. Stubenrauch, <i>Clerk to Dir.</i>

OUTLYING STATIONS.

Southern Coast Range Station, Geo. R. Adams, *Patron*, Paso Robles; Henry Tyson, *Foreman*, Paso Robles.

San Joaquin Valley Station, A. J. Pillsbury, *Patron, Tulare*; Julius Forrer, *Foreman, Tulare*.

Sierra Foothill Station, R. C. Rust, *Patron, Jackson*; Geo. Hansen, *Foreman, Jackson*.
 South California Station, Richard Gird, *Patron, Chino*; James W. Mills, *Foreman, Pomona*.

East Side Santa Clara Valley Viticultural Station, John Gallegos, *Patron, Mission San Jose*.

Chico Forestry Station, C. C. Royce, *Patron, Chico*.

Santa Monica Forestry Station, H. J. Kiruckeberg, *Patron, Santa Monica*; W. J. Stracken, *Foreman, Santa Monica*.

COLORADO.

Agricultural Experiment Station, Fort Collins.

Department of the State Agricultural College of Colorado.

GOVERNING BOARD.

A. L. Emigh (*Pres.*), *Fort Collins*; A. L. Kellogg, *Rocky Ford*; James L. Chatfield, *Gypsum*; J. S. McClelland, *Fort Collins*; James E. DuBois, *Fort Collins*; John J. Ryan, *Loveland*; Frank J. Annis, *Fort Collins*; Charles H. Small, *Pueblo*; Davis H. Waite, *Denver*; Alston Ellis, *Fort Collins*.

STATION STAFF.

Alston Ellis, M. A., PH. D., LL. D., <i>President of the College and Director</i> .	
W. W. Cooke, B. S., M. A., <i>Agr.</i>	M. J. Huffington, <i>Asst. Hort.</i>
Charles S. Crandall, M. S., <i>Bot. and Hort.</i>	R. E. Trimble, B. S., <i>Asst. Met.</i>
W. P. Headden, M. A., PH. D., <i>Chem.</i>	J. D. Stannard, B. S., <i>Asst. Irrig. Engin.</i>
Louis G. Carpenter, M. S., <i>Met. and Irrig. Engin.</i>	C. F. Baker, B. S. <i>Asst. Zoöl. and Ent.</i>
Clarence P. Gillette, M. S., <i>Ent.</i>	D. W. Working, B. S., <i>Sec.</i>
Frank L. Watrous, <i>Asst. Agr.</i>	C. H. Sheldon, <i>Treas.</i>
Charles Ryan, <i>Asst. Chem.</i>	L. M. Taylor, B. S., <i>Sten.</i>
J. H. McClelland, <i>Supt. Divide Substa., Table Rock</i> .	
Frank Beach, <i>Supt. San Luis Valley Substa., Monte Vista</i> .	
Fred A. Huntley, B. S. A., <i>Supt. Arkansas Valley Substa., Rocky Ford</i> .	

CONNECTICUT.

The Connecticut Agricultural Experiment Station, New Haven.

GOVERNING BOARD.

Gov. L. B. Morris (*Pres.*), *Hartford*; W. H. Brewer (*Sec. and Treas.*), *New Haven*; S. W. Johnson, *New Haven*; E. H. Hyde, *Stafford*; W. O. Atwater, *Middletown*; Edwin Hoyt, *New Canaan*; J. H. Webb, *Hamden*; T. S. Gold, *West Cornwall*.

STATION STAFF.

Samuel W. Johnson, M. A., <i>Dir.</i>	Wm. C. Sturgis, M. A., PH. D., <i>Myc.</i>
E. H. Jenkins, PH. D., <i>V. Dir. and Chem.</i>	J. B. Olcott, <i>Grass Agent</i> .
A. L. Winton, jr., PH. B., <i>Chem.</i>	Frances M. Bigelow, <i>Lib. and Clerk</i> .
T. B. Osborne, PH. D., <i>Chem.</i>	Charles J. Rice, <i>in Charge Buildings and Grounds</i> .
A. W. Ogden, PH. B., <i>Chem.</i>	Hugo Lange, <i>Lab. Asst.</i>
W. R. Johnston, PH. B., B. A., <i>Chem.</i>	
R. S. Curtiss, PH. D., <i>Chem.</i>	

Storrs Agricultural Experiment Station, Storrs.*

Department of Storrs Agricultural College.

GOVERNING BOARD.

Gov. L. B. Morris (*Pres.*), *Hartford*; T. S. Gold (*Sec.*), *West Cornwall*; H. C. Miles (*Treas.*), *Milford*; E. H. Hyde, *Stafford*; W. E. Simonds, *Hartford*; J. M. Hubbard, *Middletown*; J. H. Hale, *South Glastonbury*; E. C. Pinney, *Stafford*; S. W. Johnson, *New Haven*.

STATION STAFF.

B. F. Koons, PH. D., *President of the College*.
 W. O. Atwater, PH. D., *Dir. (Middle-* C. S. Phelps, B. S., *Agr.*
town). E. B. Fitts, *Asst. in Farm Expts.*
 C. D. Woods, B. S., *V. Dir. and Chem.*
(Middletown).

DELAWARE.**The Delaware College Agricultural Experiment Station, Newark.**

Department of Delaware College.

GOVERNING BOARD.

J. A. Fulton, *Dover*; Chas. C. Stockley, *Georgetown*; Jno. C. Higgins, *Delaware City*; David J. Murphy, *Newark*; James Hossinger, *Newark*; W. F. Causey, *Milford*; Manlove Hayes, *Dover*.

STATION STAFF.

A. N. Raub, PH. D., *President of the College*.
 Arthur T. Neale, PH. D., *Dir.* M. H. Beckwith, *Hort. and Ent.*
 F. D. Chester, M. S., *Myc.* C. L. Penny, M. A., *Chem.*
 W. H. Bishop, B. S., *Met.*

FLORIDA.**Agricultural Experiment Station of Florida, Lake City.**

Department of Florida State Agricultural and Mechanical College.

GOVERNING BOARD.

Walter Gwynn (*Pres.*), *Sanford*; A. B. Hagan (*Sec.*), *Lake City*; W. D. Chipley, *Pensacola*; F. E. Harris, *Ocala*; S. Stringer, *Brooksville*; S. J. Turnbull, *Monticello*; C. F. A. Bielby, *Deland*.

STATION STAFF.

O. Clute, M. S., LL. D., *President of the College and Director*.
 J. N. Whitner, M. A., *Hort.* W. G. De Pass, *Asst. Agr.*
 P. H. Rolfs, M. S., *Biol.* C. A. Finley, *Clerk*.
 A. A. Persons, M. S., *Chem.*
 L. C. Washburn, *Foreman Substa., Fort Myers*.
 J. T. Stubbs, *Foreman Substa., De Funiak Springs*.

*Telegraph address, *Storrs via Willimantic*; railroad station, express and freight address *Eagleville*.

GEORGIA.

Georgia Experiment Station, *Experiment*.*

Department of Georgia State College of Agriculture and Mechanic Arts.

GOVERNING BOARD.

R. T. Nesbitt, (*Pres.*), *Atlanta*; J. B. Park, jr. (*Sec. and Treas.*), *Greensboro*; W. E. Boggs, *Athens*; H. C. White, *Athens*; G. M. Ryals, *Savannah*; J. M. Rushin, *Boston*; Wright Brady, *Americus*; J. H. Mobley, *Hamilton*; A. J. Smith, *Conyers*; Eden Taylor, *Macon*; Felix Corput, *Cave Spring*; J. N. Twitty, *Jefferson*; W. H. Warren, *Augusta*; Ben Miliken, *Jesup*.

STATION STAFF.

H. C. White, C. E., PH. D., *President of the College*.
 R. J. Redding, *Dir.* H. N. Starnes, *Hort.*
 H. C. White, C. E., PH. D., *V. Dir. and* J. M. Kimbrough, *Agr.*
Chem. H. J. Wing, *Dairyman*.

IDAHO.

Agricultural Experiment Station of the University of Idaho, *Moscow*.

Department of the University of Idaho.

GOVERNING BOARD.

Philip Tillinghast (*Pres.*), *Moscow*; W. W. Watkins (*Sec.*), *Moscow*; R. S. Browne (*Treas.*), *Moscow*; I. C. Hattabaugh, *Moscow*; C. W. Shaff, *Lewiston*; John F. Ailshie, *Grangeville*; Sherman M. Coffin, *Caldwell*; Henry H. Hoff, *Montpelier*; A. J. Crook, *Clayton*; A. A. Crane, *Harrison*.

STATION STAFF.

Franklin B. Gault, M. S., *President of the University*.
 C. P. Fox, B. Agr., *Dir.* Louis F. Henderson, M. A., *Bot.*
 Chas. W. McCurdy, D. Sc., *Chem.* J. M. Aldrich, *Ent.*
 J. E. Ostrander, C. E., M. A., *Civil Engin.* J. E. Bonebright, *Met.*
 John Norwood, *Asst. Dir. Substa., Grangeville*.
 W. F. Cash, *Asst. Dir. Substa., Idaho Falls*.
 T. T. Rutledge, *Asst. Dir. Substa., Nampa*.

ILLINOIS.

Agricultural Experiment Station of the University of Illinois, *Champaign*.†

Department of the University of Illinois.

GOVERNING BOARD.

Geo. E. Morrow (*Pres.*), *Champaign*; E. E. Chester, *Champaign*; R. T. Fry, *Olney*; I. S. Raymond, *Sidney*; N. B. Morrison, *Odin*; Thomas J. Burrill, *Urbana*; Stephen A. Forbes, *Champaign*; Edward H. Farrington, *Champaign*.

* Telegraph, express, and freight address, *Griffin*.

† Mail should be addressed to *Agricultural Experiment Station*.

STATION STAFF.

Thomas J. Burrill, PH. D., *Acting Regent of the University.*
 George E. Morrow, M. A., *Pres. Board of Direction, and Agr.* Stephen A. Forbes, PH. D., *Consulting Ent.*
 William L. Pillsbury, M. A., *Sec.* Donald McIntosh, V. S., *Consulting Vet.*
 Thomas J. Burrill, PH. D., LL. D., *Hort. and Bot.* George W. McCluer, B. S., *Asst. Hort.*
 George P. Clinton, M. S., *Asst. Bot.*
 Edward H. Farrington, M. S., *Chem.* W. A. Powers, B. S., *Asst. Chem.*
 Frank D. Gardner, B. S., *Asst. Agr.*

INDIANA.

Agricultural Experiment Station of Indiana, La Fayette.

Department of Purdue University.

GOVERNING BOARD.

Charles B. Stuart (*Pres.*), *La Fayette*; E. A. Ellsworth (*Sec.*), *La Fayette*; J. M. Fowler (*Treas.*), *La Fayette*; William A. Banks, *La Porte*; Sylvester Johnson, *Irvington*; D. E. Beem, *Spencer*; J. N. Davidson, *Whitesville*; J. M. Dresser, *La Fayette*.

STATION STAFF.

James H. Smart, M. A., LL. D., *President of the University.*
 Charles S. Plumb, B. S., *Dir.* Joseph C. Arthur, D. Sc., *Bot.*
 William C. Latta, M. S., *Agr.* A. W. Bitting, V. S., *Vet.*
 James Troop, M. S., *Hort.* S. G. Wright, M. S., *Asst. Bot.*
 Henry A. Huston, M. A., A. C., *Chem.* Wm. Brady, M. S., A. C., *Asst. Chem.*
 Geo. R. Ives, B. S., *Asst. Agr.*

IOWA.

Iowa Agricultural Experiment Station, Ames.

Department of Iowa State College of Agriculture and Mechanic Arts.

GOVERNING BOARD.

J. H. Wood (*Chair.*), *Atlantic*; E. W. Stanton (*Sec.*), *Ames*; Herman Knapp (*Treas.*), *Ames*; C. M. Dunbar, *Maquoketa*; Hamilton Smith, *Fairfield*; J. S. Jones, *Manchester*; Addis Schermerhorn, *Charles City*; A. B. Shaw, *Corning*; W. O. McElroy, *Newton*; C. F. Saylor, *Des Moines*; Cato Sells, *Vinton*; Eugene Secor, *Forest City*; C. D. Boardman, *Odebolt*.

STATION STAFF.

W. M. Beardshear, M. A., *President of the College.*
 James Wilson, *Dir.* D. A. Kent, B. S., *Asst. Agr.*
 C. F. Curtiss, B. S. A., *Asst. Dir.* W. B. Niles, D. V. M., *Asst. Vet.*
 G. E. Patrick, M. S., *Chem.* F. C. Stewart, *Asst. Bot.*
 L. H. Pammel, B. Agr., M. S., *Bot.* ———, *Asst. Chem.*
 Herbert Osborn, M. S., *Ent.* F. A. Sirrene, *Asst. Ent.*
 J. L. Budd, M. H., *Hort.* H. C. Wallace, *Dairyman.*
 M. Stalker, M. S., V. S., *Vet.* N. E. Hansen, *Asst. Hort.*

KANSAS.

Kansas Agricultural Experiment Station, *Manhattan*.

Department of Kansas State Agricultural College.

GOVERNING BOARD.

A. P. Forsyth (*Pres.*), *Liberty*; Geo. T. Fairchild (*Sec.*), *Manhattan*; Joshua Wheeler (*Treas.*), *Nortonville*; W. D. Street, *Oberlin*; E. D. Stratford, *El Dorado*; Ed. Secrest, *Randolph*; Harrison Kelley, *Burlington*.

STATION STAFF.

George T. Fairchild, LL. D., <i>President of the College and Chairman of Station Council.</i>	
George H. Failyer, M. S., <i>Chem.</i>	Julius T. Willard, M. S., <i>Asst. Chem.</i>
Edwin A. Popenoe, M. A., <i>Hort. and Ent.</i>	Silas C. Mason, M. S., <i>Asst. Hort. and Foreman Gardens.</i>
Charles C. Georgeson, M. S., <i>Agr.</i>	
Nelson S. Mayo, D. V. S., M. S., <i>Physiol. and Vet.</i>	Frederick A. Marlatt, B. S., <i>Asst. Ent.</i>
	Frank C. Burtis, B. S., <i>Asst. Agr.</i>
A. S. Hitchcock, M. S., <i>Bot.</i>	Daniel H. Otis, B. S., <i>Asst. Agr.</i>
I. D. Graham, B. S., M. A., <i>Sec.</i>	M. A. Carleton, M. S., <i>Asst. Bot.</i>

KENTUCKY.

Kentucky Agricultural Experiment Station, *Lexington*.

Department of the Agricultural and Mechanical College of Kentucky.

GOVERNING BOARD.

R. J. Spurr (*Chair.*), *Greendale*; M. A. Scovell. (*Sec.*) *Lexington*; R. S. Bullock (*Treas.*), *Lexington*; W. B. Kinkead, *Lexington*; D. C. Buell, *Paradise*; W. L. Davis, *Paris*; Hart Gibson, *Lexington*; James K. Patterson, *Lexington*.

STATION STAFF.

James K. Patterson, Ph. D., <i>President of the College.</i>	
M. A. Scovell, M. S., <i>Dir.</i>	S. E. Bennett, D. V. M., <i>Vet.</i>
A. M. Peter, M. S., <i>Chem.</i>	C. W. Mathews, B. S., <i>Hort.</i>
H. E. Curtis, M. S., <i>Chem.</i>	A. T. Jordan, <i>Asst. Hort.</i>
H. Garman, <i>Ent. and Bot.</i>	Alice M. Shelby, <i>Sten.</i>
J. S. Terrill, B. S., <i>Asst. Ent. and Bot.</i>	T. S. Hawkins, <i>Foreman Farm.</i>

LOUISIANA.

No. 1. Sugar Experiment Station, *Audubon Park, New Orleans*.

No. 2. State Experiment Station, *Baton Rouge*.

No. 3. North Louisiana Experiment Station, *Calhoun*.

Department of Louisiana State University and Agricultural and Mechanical College.

GOVERNING BOARD.

Gov. Murphy J. Foster (*Pres.*), *Baton Rouge*; D. D. Colcock (*Sec.*), *Sugar Exchange, New Orleans*; H. Skolfield (*Treas.*), *Baton Rouge*; H. C. Newsom, *Baton Rouge*; William Garig, *Baton Rouge*.

STATION STAFF.

J. W. Nicholson, M. A., LL.D., *President of the College (Baton Rouge).*

Sugar Experiment Station, *Audubon Park, New Orleans.*

Wm. C. Stubbs, M. A., PH. D., <i>Dir.</i>	Adolph Lehman, B. S. A., <i>Chem.</i>
T. P. Hutchinson, <i>Asst. Dir.</i>	R. T. Burwell, M. E., <i>Machinist.</i>
Walter Maxwell, PH. D., <i>Chem.</i>	E. E. Olding, <i>Sugar Maker.</i>
J. L. Beeson, PH. D., <i>Chem.</i>	E. G. Clarke, <i>Farm Manager.</i>
Jas. K. McHugh, <i>Sec.</i>	

State Experiment Station, *Baton Rouge.*

Wm. C. Stubbs, M. A., PH. D., <i>Dir.</i>	W. W. Clendennin, B. S., M. A., <i>Bot.</i>
D. N. Barrow, B. S., <i>Asst. Dir.</i>	S. B. Staples, B. S., D. V. S., <i>Vet.</i>
J. P. Coates, PH. D., <i>Chem.</i>	H. A. Morgan, B. S. A., <i>Ent. and Hort.</i>
R. E. Blouin, B. S., <i>Asst. Chem.</i>	F. H. Burnette, <i>Hort.</i>
W. B. Mercier, <i>Farm Manager.</i>	

North Louisiana Experiment Station, *Calhoun.*

Wm. C. Stubbs, M. A., PH. D., <i>Dir.</i>	Maurice Bird, B. S., <i>Chem.</i>
Jordan G. Lee, B. S., <i>Asst. Dir.</i>	Thos. I. Watson, <i>Farm Manager.</i>
Eugene J. Watson, <i>In Charge of Stock.</i>	

MAINE.

Maine State College Agricultural Experiment Station, *Orono.*

Department of Maine State College.

GOVERNING BOARD.

A. W. Harris (*Pres.*), *Orono*; Whitman H. Jordan (*Sec.*), *Orono*; Rutillus Alden, *Winthrop*; B. F. Briggs, *Auburn*; Arthur L. Moore, *Limerick*; Walter Balentine, *Orono*; F. L. Harvey, *Orono*; F. L. Russell, *Orono*; W. M. Munson, *Orono*; B. W. McKeen, *Eryeburg*; D. H. Knowlton, *Farmington*; I. O. Winslow, *St. Albans.*

STATION STAFF.

A. W. Harris, M. A., PH. D., <i>President of the College.</i>	
Whitman H. Jordan, M. S., <i>Dir.</i>	L. H. Merrill, B. S., <i>Chem.</i>
Walter Balentine, M. S., <i>Agr.</i>	W. M. Munson, M. S., <i>Hort.</i>
F. L. Harvey, PH. D., <i>Bot. and Ent.</i>	F. P. Briggs, B. S., <i>Asst. Bot. and Ent.</i>
Merritt C. Fernald, PH. D., <i>Met.</i>	H. P. Gould, <i>Asst. Hort.</i>
F. L. Russell, B. S., V. S., <i>Vet.</i>	A. M. Shaw, <i>Foreman Farm.</i>
J. M. Bartlett, M. S., <i>Chem.</i>	Mrs. J. Hamlin Waitt, <i>Sten. and Clerk.</i>

MARYLAND.

Maryland Agricultural Experiment Station, *College Park.*

Department of Maryland Agricultural College.

GOVERNING BOARD.

Gov. Frank Brown (*Pres.*), *Annapolis*; Marion De Kalb Smith, *Chestertown*; Murray Vandiver, *Havre de Grace*; Spencer C. Jones, *Rockville*; David Seibert, *Clear Spring*; Clayton J. Purnell, *Snow Hill.*

STATION STAFF.

R. W. Silvester, *President of the College.*
 Robert H. Miller, *Dir. and Agr.* Milton Whitney, *Physicist.*
 Harry J. Patterson, B. S., *Chem.* Earnest H. Brinkley, *Asst. Agr.*
 J. S. Robinson, *Hort.* Jos. R. Owens, M. D., *Treas.*
 C. V. Riley, PH. D., *Ent. and Physiol.*

MASSACHUSETTS.

Massachusetts State Agricultural Experiment Station, Amherst.

GOVERNING BOARD.

Gov. E. B. Greenhalge (*Pres.*), *Boston*; Wm. R. Sessions (*Sec.*), *Hampden*; Charles A. Goessmann (*Treas.*), *Amherst*; W. H. Bowker, *Boston*; Calvin L. Hartshorn, *Worcester*; J. H. Demond, *Northampton*; E. D. Howe, *Marlboro*; F. H. Appleton, *Peabody*; W. H. Porter, *Agawam*; William C. Strong, *Newton Highlands*; H. H. Goodell, *Amherst*.

STATION STAFF.

Charles A. Goessmann, PH. D., LL. D., *Dir. and Chem.* F. L. Arnold, B. S., *Asst. Chem.*
 Joseph B. Lindsey, PH. D., *Assoc. Chem.* E. B. Holland, *Asst. Chem. and Asst. in Stock Feeding.*
 C. S. Crocker, B. S., *Asst. Chem.* R. H. Smith, *Asst. Chem. and Asst. in Field Experiments.*
 H. D. Haskins, B. A., *Asst. Chem.* L. E. Goessmann, *Asst. Chem. and Clerk.*
 C. H. Jones, B. S., *Asst. Chem.* David Wentzell, *Farmer.*
 C. H. Johnson, B. S., *Asst. Chem. and Asst. in Stock Feeding.*

Hatch Experiment Station of the Massachusetts Agricultural College, Amherst.

Department of the Massachusetts Agricultural College.

GOVERNING BOARD.

William R. Sessions (*Chair.*), *Commonwealth Building, Boston*; Daniel Needham, *Groton*; William Wheeler, *Concord*; James Draper, *Worcester*; Elijah W. Wood, *West Newton*; Henry H. Goodell, *Amherst*.

STATION STAFF.

H. H. Goodell, M. A., LL. D., *President of the College and Director.*
 William P. Brooks, B. S., *Agr.* Henry M. Thomson, *Asst. Agr.*
 Samuel T. Maynard, B. S., *Hort.* M. A. Carpenter, *Asst. Hort.*
 Chas. H. Fernald, M. A., PH. D., *Ent.* A. H. Kirkland, *Asst. Ent.*
 Clarence D. Warner, B. S., *Met.* C. P. Lounsbury, *Asst. Ent.*
 William M. Shepardson, B. S., *Asst. Hort.* George F. Mills, *Treas.*
 Chas. A. Gleason, *Auditor (New Braintree).*

MICHIGAN.

Experiment Station of Michigan Agricultural College, Agricultural College.*

Department of Michigan Agricultural College.

GOVERNING BOARD.

Franklin Wells (*Pres.*), *Constantine*; C. F. Moore, *St. Clair*; Chas. W. Garfield, *Grand Rapids*; Gov. Jno. T. Rich, *Lansing*; A. C. Glidden, *Paw Paw*; Henry Chamberlain, *Three Oaks*; Edwin Phelps, *Pontiac*; L. G. Gorton, *Agricultural College*.

* Telegraph, express, and freight address, *Lansing*.

STATION STAFF.

L. G. Gorton, *President of the College and Director.*

C. D. Smith, M. S., <i>Agr.</i>	H. P. Gladden, B. S., <i>Asst. Hort.</i>
Robert C. Kedzie, M. A., M. D., <i>Chem.</i>	W. L. Rossman, B. S., <i>Asst. Chem.</i>
C. F. Wheeler, B. S., <i>Bot.</i>	H. E. Harrison, B. S., <i>Asst. Chem.</i>
G. C. Davis, M. S., <i>Zoöl.</i>	Mrs. L. E. Landon, <i>Lib.</i>
L. R. Taft, M. S., <i>Hort.</i>	A. T. Stevens, B. S., <i>Asst. Agr.</i>
E. A. A. Grange, V. S., <i>Vet.</i>	R. J. Coryell, B. S., <i>Asst. Hort.</i>
I. H. Butterfield, <i>Sec. and Treas.</i>	
H. M. Howe, <i>Asst. to Dir.</i>	

MINNESOTA.

Agricultural Experiment Station of the University of Minnesota, St. Anthony Park.

Department of University of Minnesota.

GOVERNING BOARD.

John S. Pillsbury (*Pres.*), *Minneapolis*; O. C. Merriam (*Treas.*), *Minneapolis*; Cyrus Northrop, *Minneapolis*; Greenleaf Clark, *St. Paul*; Cushman K. Davis, *St. Paul*; Knute Nelson, *Alexandria*; Joel P. Heatwole, *Northfield*; O. P. Stearns, *Duluth*; William M. Liggett, *Benson*; S. M. Owen, *Minneapolis*; Stephen Mahoney, *Minneapolis*; W. W. Pendergast, *Hutchinson*.

STATION STAFF.

Cyrus Northrop, LL. D., *President of the College.*

W. M. Liggett, <i>Chair.</i>	M. H. Reynolds, M. D., V. M., <i>Vet.</i>
W. M. Hays, B. S. A., <i>V. Chair and Agr.</i>	T. L. Haecker, <i>Dairy Husbandry.</i>
Samuel B. Green, B. S., <i>Hort.</i>	Thos. Shaw, <i>Animal Husbandry.</i>
Otto Lugger, Ph. D., <i>Ent. and Bot.</i>	Andrew Boss, <i>Foreman Farm.</i>
Harry Snyder, B. S., <i>Chem.</i>	J. A. Vye, <i>Sec.</i>

MISSISSIPPI.

Mississippi Agricultural Experiment Station, Agricultural College.*

Department of Mississippi Agricultural and Mechanical College.

GOVERNING BOARD.

Gov. J. M. Stone (*Pres.*), *Jackson*; H. M. Street, *Meridian*; J. Z. George, *Carrollton*; F. McCormick, *Perkinston*; Geo. H. Peets, *Woodville*; J. R. Cameron, *Canton*; W. B. Montgomery, *Starkville*; T. C. Dockery, *Love's Station*; A. F. Fox, *West Point*; W. H. Morgan, *Sheppardtown*; S. D. Lee, *Agricultural College*; S. M. Tracy, *Agricultural College*.

STATION STAFF.

S. D. Lee, *President of the College.*

S. M. Tracy, M. S., <i>Dir.</i>	Tait Butler, V. S., <i>Vet.</i>
E. R. Lloyd, M. S., <i>Agr.</i>	W. L. Hutchinson, M. S., <i>Chem.</i>
H. E. Weed, M. S., <i>Ent.</i>	L. G. Patterson, <i>Chem.</i>
A. B. McKay, B. S., <i>Hort.</i>	R. C. King, <i>Treas.</i>

F. S. Earle, *Supt. Substa., Ocean Springs.*
 G. J. Finley, *Supt. Substa., Holly Springs.*
 J. B. Bailey, *Supt. Substa., Lake.*
 D. T. Price, *Supt. Substa., Booneville.*

* Express and telegraph address Starkville.

MISSOURI.

Missouri Agricultural College Experiment Station, Columbia.

Department of the College of Agriculture and Mechanic Arts of the University of Missouri.

GOVERNING BOARD.

G. F. Rothwell (*Pres.*), *Moberly*; R. B. Price (*Treas.*), *Columbia*; B. M. Dilley, *Hamilton*; J. S. Clarkson, *Columbia*.

STATION STAFF.

Richard H. Jesse, LL. D., *President of the College*.

Edward D. Porter, M. A., PH. D., <i>Dir.</i>	————— <i>Asst. Agr.</i>
and <i>Agr.</i>	A. C. Vandiver, <i>Farm Supt.</i>
Paul Schweitzer, PH. D., <i>Chem.</i>	Irvin Switzler, <i>Sec.</i>
Charles H. Keffer, M. H., <i>Hort.</i>	R. Beverly Price, <i>Treas.</i>

MONTANA.

Montana Agricultural Experiment Station, Bozeman;

Department of Montana Agricultural College.

GOVERNING BOARD.

L. S. Willson, (*Pres.*), *Bozeman*; Peter Koch (*Sec. and Treas.*) *Bozeman*; Walter Cooper, *Bozeman*; Geo. Kinkel, jr., *Manhattan*; E. H. Talcott, *Bozeman*.

STATION STAFF.

A. N. Ryon, *President of the College*.

S. M. Emery, <i>Dir. and Hort.</i>	F. W. Traphagen, PH. D., <i>Chem.</i>
Luther Foster, M. S. A., <i>Agr.</i>	W. L. Williams, <i>Vet.</i>
H. G. Phelps, <i>Accountant</i> .	

NEBRASKA.

Agricultural Experiment Station of Nebraska, Lincoln.

Department of the University of Nebraska.

GOVERNING BOARD.

Charles H. Morrill (*Pres.*), *Lincoln*; J. S. Dales (*Sec. and Treas.*), *Lincoln*; J. L. H. Knight; *Lee Park*; C. W. Kaley, *Red Cloud*; E. A. Hadley, *Scotia*; H. D. Easterbrook, *Omaha*; Chas. Weston, *Hay Springs*.

STATION STAFF.

James H. Canfield, M. A., *Chancellor of the University*.

C. L. Ingersoll, M. Sc., <i>Dir. and Agr.</i>	A. T. Peters, V. S., <i>Vet.</i>
H. H. Nicholson, M. A., <i>Chem.</i>	E. H. Barbour, PH. D., <i>Geol.</i>
C. E. Bessey, PH. D., <i>Bot.</i>	J. C. White, B. S., <i>Asst. Chem.</i>
D. B. Brace, M. A., PH. D., <i>Physics</i> .	A. M. Troyer, B. S., <i>Asst. Agr.</i>
Lawrence Bruner, <i>Ent.</i>	S. W. Perin, <i>Foreman Farm.</i>
F. W. Card, M. S., <i>Hort.</i>	C. Y. Smith, <i>Executive Clerk.</i>

NEVADA.

Nevada Agricultural Experiment Station, Reno.

Department of Nevada State University.

GOVERNING BOARD.

H. L. Fish (*Pres.*), *Reno*; Geo. H. Taylor (*Sec.*), *Reno*; T. R. Hofer (*Treas.*), *Carson City*; Gov. R. K. Colcord, *Carson City*; J. D. Torreyson, *Carson City*; J. W. Haines, *Genoa*; C. E. Mack, *Virginia City*.

STATION STAFF.

Stephen A. Jones, M. A., PH. D., *President of the College and Director*.
 Fred H. Hillman, M.S., *Ent and Bot.* Nathaniel E. Wilson, M. S., *Chem.*
 Ransom H. McDowell, B. S., *Agr. and Hort.* Hannah K. Clapp, M. A., *Lib.*
 R. A. Lounsbury, *Foreman Farm.*

NEW HAMPSHIRE.

New Hampshire Agricultural Experiment Station, Durham.

Department of New Hampshire College of Agriculture and the Mechanic Arts.

GOVERNING BOARD.

Geo. A. Wason (*Pres.*), *New Boston*; C. W. Stone (*Sec.*), *East Andover*; Chas. S. Murkland, *Durham*; John G. Tallant, *Pembroke*; Henry Keys, *North Haverhill*.

STATION STAFF.

Chas S. Murkland, PH. D., *President of the College*.
 G. H. Whitcher, B. S., *Dir.* C. H. Pettee, M. A., C. E., *Met.*
 A. H. Wood, B. S., *Supt. Dairy Dept.* C. M. Weed, D. Sc., *Ent.*
 H. H. Lamson, M. D., *Bact.* D. E. Stone, B. S., *Foreman Farm.*
 F. W. Morse, B. S., *Chem.* E. P. Stone, *Asst. Chem.*
 C. L. Parsons, B. S., *Chem.* F. D. Fuller, *Lab. Asst.*

NEW JERSEY.

New Jersey State Agricultural Experiment Station, New Brunswick.

At Rutgers College.

GOVERNING BOARD.

Abraham W. Duryee (*Pres.*), *New Durham*; William R. Ward (*Sec.*), *Newark*; I. S. Upson, (*Treas.*), *New Brunswick*; Gov. G. T. Wertz, *Trenton*; Austin Scott, *New Brunswick*; Edward B. Voorhees, *New Brunswick*; Henry Frederick, *Camden*; Daniel W. Horner, *Merchantville*; Joshua Forsyth, *Pemberton*; Ralph Ege, *Hopewell*; W. H. Green, *Succasunna*; B. F. Tine, *Stanton*; J. B. Rogers, *Newark*; C. L. Jones, *Newark*; Jas. McCarthy, *442 Garfield Ave., Jersey City*; G. W. Doty, *Union*; James Neilson, *New Brunswick*; David D. Denise, *Freehold*; Samuel R. Demarest, jr., *Hackensack*; James Stevens, *287 Communipaw Ave., Jersey City*.

STATION STAFF.

Edward B. Voorhees, M. A., *Dir. and Chem.* Irving S. Upson, M. A., *Chief Clerk*.
 Mary A. Whitaker, *Sten.*
 Louis A. Voorhees, M. A., *Chem.* Richard Titus, *Janitor and Lab. Attendant*.
 John P. Street, B. S., *Chem.*

New Jersey Agricultural College Experiment Station, New Brunswick.

Department of Rutgers College.

GOVERNING BOARD.

Austin Scott (*Chair.*), *New Brunswick*; Frederick Frelinghuysen (*Treas.*), *Newark*; Geo. C. Ludlow, *New Brunswick*; Henry W. Bookstaver, *14 East Sixty-Seventh St., New York City*; Henry R. Baldwin, *New Brunswick*; James Neilson, *New Brunswick*.

STATION STAFF.

Austin Scott, PH. D., LL. D., *President of the College and Director.*
 Julius Nelson, PH. D., *Biol.* Leonora E. Burwell, *Sten.*
 B. D. Halsted, D. Sc., *Bot. and Hort.* Augusta Meske, *Sten.*
 John B. Smith, D. Sc. *Ent.* Chas. A. Poulson, *Mailing Asst.*
 E. A. Jones, *Supt. College Farm.*
 Irving S. Upson, M. A., *Disbursing Clerk and Lib.*

NEW MEXICO.**Agricultural Experiment Station of New Mexico, Las Cruces.**

Department of New Mexico College of Agriculture and Mechanic Arts.

GOVERNING BOARD.

John R. McFie (*Pres.*), *Las Cruces*; T. J. Bull (*Sec. and Treas.*), *Mesilla*; J. D. W. Veeder, *Las Vegas*; Robert Black, *Silver City*; Demetrio Chavez, *Mesilla*.

STATION STAFF.

Hiram Hadley, M. A., *President of the College and Director.*
 Ainsworth E. Blount, M. A., *Hort. and Agr.* T. D. A. Cockerell, *Ent. and Zoöl.*
 Elmer O. Wooton, B. S., *Chem.* Harvey H. Griffin, B. S., *Asst. Agr. and Hort.*
 Arthur Goss, B. S., A. C., *Chem.* Frank E. Lester, *Clerk.*
 R. F. Hare, M. S., *Asst. Chem.*

NEW YORK.**New York Agricultural Experiment Station, Geneva.**

GOVERNING BOARD.

W. C. Barry (*Pres.*), *Rochester*; W. O'Hanlon (*Sec. and Treas.*), *Geneva*; Gov. R. P. Flower, *Albany*; Charles Jones, *Geneseo*; George F. Mills, *Fonda*; Philip N. Nicholas, *Geneva*; Adrian Tuttle, *Watkins*; W. D. Barnes, *Middle Hope*; M. V. B. Ives, *Potsdam*; L. D. Olney, *Watertown*; S. H. Hammond, *Geneva*.

STATION STAFF.

Peter Collier, M. A., M. D., PH. D., *Dir.* A. L. Knisely, M. S., *Asst. Chem.*
 Wm. P. Wheeler, *Asst. Dir.* W. B. Cady, PH. C., *Asst. Chem.*
 L. L. Van Slyke, M. A., PH. D., *Chem.* B. L. Murray, PH. C., *Asst. Chem.*
 S. A. Beach, M. S., *Hort.* A. D. Cook, PH. C., *Asst. Chem.*
 W. Paddock, B. S., *Asst. Hort.* H. Kahn, PHAR. M., *Asst. Chem.*
 C. G. Jenter, PH. C., *Asst. Chem.* George W. Churchill, *Agr.*
 Frank E. Newton, *Clerk and Sten.*

Cornell University Agricultural Experiment Station, Ithaca.

Department of Cornell University.

GOVERNING BOARD.

Jacob G. Schurman (*Pres.*), Andrew D. White; J. B. Dutcher; (*Pawling, N. Y.*); Isaac P. Roberts, George C. Caldwell, James Law, Albert N. Prentiss, John H. Comstock, Liberty H. Bailey, Henry H. Wing, George F. Atkinson.

STATION STAFF.

Jacob G. Schurman, B. A., D. Sc., LL. D., <i>President of the College.</i>	
Isaac P. Roberts, M. AGR., <i>Dir. and Agr.</i>	Liberty H. Bailey, M. S., <i>Hort.</i>
Henry H. Wing, B. AGR., M. S., <i>Deputy Dir. and Sec.</i>	George F. Atkinson, M. S., <i>Crypt. Bot.</i>
Emmons L. Williams, <i>Treas.</i>	Mark V. Slingerland, B. S., <i>Asst. Ent.</i>
George C. Caldwell, Ph. D., <i>Chem.</i>	George C. Watson, B. AGR., M. S., <i>Asst. Agr.</i>
James Law, F. R. C. V. S., <i>Vet.</i>	George W. Cavanaugh, <i>Asst. Chem.</i>
Albert N. Prentiss, M. S., <i>Bot. and Arbor.</i>	E. G. Lodeman, B. S., <i>Asst. Hort.</i>
John H. Comstock, B. S. <i>Ent.</i>	T. Brill, jr., <i>Foreman Farm.</i>

NORTH CAROLINA.**North Carolina Agricultural Experiment Station, Raleigh.**

GOVERNING BOARD.

W. S. Primrose (*Pres.*), *Raleigh*; W. F. Green, *Franklinton*; D. A. Tompkins, *Charlotte*; Henry E. Fries, *Salem*; N. B. Broughton, *Raleigh*; J. R. McLelland, *Mooreville*; J. B. Coffield, *Everetts*; W. R. Williams, *Falkland*; R. W. Wharton, *Washington*; C. D. Smith, *Franklin*; W. R. Capehart, *Avoca*; J. F. Payne, *Alma*; J. H. Gilmer, *Greensboro*; W. E. Stevens, *Clinton*.

STATION STAFF.

H. B. Battle, Ph. D., <i>Dir. and Chem.</i>	F. B. Carpenter, B. S., <i>Asst. Chem.</i>
F. E. Emery, B. S., <i>Agr.</i>	W. M. Allen, <i>Asst. Chem.</i>
Gerald McCarthy, B. S., <i>Bot. and Ent.</i>	C. B. Williams, B. S., <i>Asst. Chem.</i>
W. F. Massey, C. E., <i>Hort.</i>	Alexander Rhodes, <i>Asst. Hort.</i>
C. F. Von Hermanu, <i>Met.</i>	Roscoe Nunn, <i>Asst. Met.</i>
B. W. Kilgore, M. S., <i>Asst. Chem.</i>	A. F. Bowen, <i>Sec.</i>

NORTH DAKOTA.**North Dakota Agricultural Experiment Station, Fargo.**

Department of North Dakota Agricultural College.

GOVERNING BOARD.

H. F. Miller (*Pres.*), *Fargo*; J. B. Power, *Power*; Jacob Lowell, *Fargo*; Peter McKenna, *Fargo*; Joseph Deschenes, *Grafton*; A. M. Tofthagen, *Lakota*.

STATION STAFF.

J. B. Power, <i>President of the College and Director.</i>	
E. F. Ladd, B. S., <i>Chem.</i>	C. B. Waldron, B. S., <i>Arbor.</i>
J. H. Shepperd, M. S. A., <i>Agr.</i>	H. L. Bolley, M. S., <i>Bot.</i>
T. D. Hinebauch, M. S., V. S., <i>Vet.</i>	W. G. Hiatt, <i>Farm Supt.</i>
Wm. G. Hayden, <i>Sec.</i>	

OHIO.

Ohio Agricultural Experiment Station, Wooster.

GOVERNING BOARD.

Seth H. Ellis (*Pres.*), *Springboro*; R. H. Warder, (*Sec.*), *North Bend*; Joseph H. Brigham, *Delta*; Gov. Wm. McKinley, jr., *Columbus*; Chas. E. Thorne, *Wooster*.

STATION STAFF.

Charles E. Thorne, <i>Dir.</i>	E. C. Green, <i>Asst. Hort.</i>
William J. Green, <i>V. Dir. and Hort.</i>	F. J. Falkenbach, <i>Chem.</i>
J. Fremont Hickman, M. A. S., <i>Agr.</i>	Bertha E. Wildman, <i>Treas.</i>
F. M. Webster, <i>Ent.</i>	J. S. Hine, <i>Supt. Substa.</i>

OKLAHOMA.

Oklahoma Agricultural Experiment Station, Stillwater.

Department of Agricultural and Mechanical College, Oklahoma.

GOVERNING BOARD.

C. O. Blake (*Pres.*), *El Reno*; J. E. Quein (*Sec.*), *Edmond*; A. A. Ewing (*Treas.*), *Kingfisher*; Gov. W. C. Renfrow, *Guthrie*; W. H. Campbell, *Orlando*; J. C. Fletcher, *Chandler*.

STATION STAFF.

R. J. Barker, <i>President of the College.</i>	
J. C. Neal, Ph. C., M. D., <i>Dir., Bot. and Ent.</i>	A. N. Caudell, <i>Asst. Ent.</i>
A. C. Magruder, B. S., <i>Agr.</i>	W. T. Webster, <i>Mechanic.</i>
F. A. Waugh, B. S., <i>Hort.</i>	A. V. McDowell, <i>Supt. Farm.</i>
George L. Holter, B. S., <i>Chem.</i>	

OREGON.

Oregon Experiment Station, Corvallis.

Department of Oregon State Agricultural College.

GOVERNING BOARD.

Gov. Sylvester Pennoyer (*Pres.*), *Portland*; Wallis Nash (*Sec.*), *Corvallis*; A. R. Shipley (*Treas.*) *Corvallis*; G. W. McBride, *Salem*; Bernard Daly, *Lakeriew*; E. B. McElroy, *Salem*; R. P. Boise, *Salem*; T. W. Davenport, *Silverton*; John Emmett, *Umpqua Ferry*; W. P. Keady, *Portland*; J. K. Weatherford, *Albany*; W. A. Sample, *Pendleton*; J. T. Apperson, *Oregon City*.

STATION STAFF.

J. M. Bloss, M. A., <i>President of the College and Director.</i>	
H. T. French, M. S., <i>Agr.</i>	George Coote, <i>Hort.</i>
F. L. Washburn, B. A., <i>Ent.</i>	Moses Craig, M. S., <i>Bot.</i>
J. F. Fulton, B. S., A. C., <i>Chem.</i>	

PENNSYLVANIA.

The Pennsylvania State College Agricultural Experiment Station, State College.

Department of the Pennsylvania State College.

GOVERNING BOARD.

John A. Woodward (*Chair.*), *Howard*; H. P. Armsby (*Sec.*), *State College*; George W. Atherton, *State College*; Samuel R. Downing, *West Chester*; Amos H. Myln, *Lancaster*; Joel A. Herr, *Cedar Springs*.

STATION STAFF.

George W. Atherton, LL. D., <i>President of the College.</i>	
H. P. Armsby, PH. D., <i>Dir.</i>	W. S. Sweetser, B. S., <i>Asst. Chem.</i>
William Frear, B. A., PH. D., <i>V. Dir. and Chem.</i>	J. A. Fries, <i>Asst. Chem.</i>
William A. Buckhout, M. S., <i>Bot.</i>	J. W. Fields, B. S., <i>Asst. Chem.</i>
Geo. C. Butz, M. S., <i>Hort.</i>	E. J. Haley, M. A., <i>Asst. Chem.</i>
H. J. Waters, B. S. A., <i>Agr.</i>	M. E. McDonnell, <i>Asst. Chem.</i>
William C. Patterson, <i>Supt. Farm.</i>	George Baldwin, <i>Gardener.</i>
Julia C. Gray, <i>Sec.</i>	R. J. Weld, <i>Asst. in Field and Feeding Experiments.</i>
William H. Caldwell, B. S., <i>Asst. Agr.</i>	

RHODE ISLAND.

Rhode Island Agricultural Experiment Station, Kingston.

Department of Rhode Island College of Agriculture and Mechanic Arts.

GOVERNING BOARD.

Charles O. Flagg (*Pres.*), *Kingston*; Charles J. Green (*Sec.*), *Kenyon*; Melville Bull (*Treas.*), *Newport*; Nathan D. Pierce, jr., *Norwood*; C. H. Coggeshall, *Bristol*.

STATION STAFF.

John H. Washburn, PH. D., <i>President of the College.</i>	
Charles O. Flagg, B. Sc., <i>Dir. and Agr.</i>	J. D. Towar, B. Sc., <i>Asst. Agr.</i>
L. F. Kinney, B. Sc., <i>Hort.</i>	B. L. Hartwell, B. Sc., <i>Asst. Chem.</i>
H. J. Wheeler, B. Sc., PH. D., <i>Chem.</i>	H. F. Adams, <i>Farmer.</i>
Samuel Cushman, <i>Apiarist and Poultry Manager.</i>	A. R. French, <i>Clerk.</i>

SOUTH CAROLINA.

South Carolina Agricultural Experiment Station, Clemson College.*

Department of Clemson Agricultural College.

GOVERNING BOARD.

R. W. Simpson (*Pres.*), *Pendleton*; P. H. E. Sloan (*Sec. and Treas.*), *Clemson College*; D. K. Norris, *Hickory Flat*; M. L. Donaldson, *Greenville*; R. E. Bowen, *Briggs*; Jesse H. Hardin, *Chester*; Gov. B. R. Tillman, *Columbia*; J. E. Bradley, *Hunters*; H. M. Stackhouse, *Clio*; J. E. Tindal, *Columbia*; Alan Johnstone, *Newbury*; J. E. Wannamaker, *St. Matthews*; Jas. L. Orr, *Greenville*; D. T. Redfearn, *Mt. Groghan*.

* Telegraph, express, and freight address, *Calhoun Station*.

STATION STAFF.

E. B. Craighead, <i>President of the College and Director.</i>	
W. L. McGee, M. S., <i>Agr.</i>	F. S. Shiver, PH. G., <i>Asst. Chem.</i>
M. B. Hardin, <i>Chem.</i>	R. N. Brackett, PH. D., <i>Asst. Chem.</i>
Clough W. Sims, M. A., <i>Asst. Chem.</i>	J. F. C. Du Pre, <i>Asst. Hort.</i>
J. W. Hart, <i>Dairyman.</i>	W. D. James, <i>Foreman Farm.</i>
L. A. Clinton, <i>Asst. Agr.</i>	J. N. Hook, <i>Clerk.</i>

SOUTH DAKOTA.

South Dakota Agricultural Experiment Station, Brookings.

Department of South Dakota Agricultural College.

GOVERNING BOARD.

E. T. Sheldon (*Pres.*), *St. Lawrence*; F. G. Hale (*Treas.*), *Scotland*; Lewis McLouth, (*Sec.*), *Brookings*; C. H. Collins, *Brookings*; L. K. Larson, *Dell Rapids*; J. G. Carter, *Aberdeen*; John Giese, *Watertown*.

STATION STAFF.

Lewis McLouth, M. A., PH. D., <i>President of the College and of Station Council.</i>	
E. C. Chilcott, <i>Agr.</i>	H. B. Mathews, <i>Met.</i>
L. C. Corbett, B. S., <i>Hort.</i>	Fred K. Luke, <i>Asst. Hort.</i>
A. H. Wheaton, <i>Dairyman.</i>	L. E. Winslow, <i>Sten.</i>
D. A. Cormack, <i>Vet.</i>	C. G. Hopkins, B. S., <i>Asst. Chem.</i>
H. N. Ott, <i>Animal Pathology.</i>	John M. Parkinson, <i>Lib.</i>
T. A. Williams, M. A., <i>Bot. and Ent.</i>	A. W. Williams, <i>Foreman of Farm.</i>
Jas. H. Shepard, B. S., <i>Chem.</i>	Ed. F. Hewit, <i>Sec. and Accountant.</i>

TENNESSEE.

Tennessee Agricultural Experiment Station, Knoxville.

Department of the University of Tennessee.

GOVERNING BOARD.

M. P. Jarnagin (*Pres.*), *Mossy Creek*; J. W. Gaut (*Sec.*), *Knoxville*; James Comfort (*Treas.*), *Knoxville*; O. P. Temple, *Knoxville*; Joseph W. Allison, *Memphis*; W. H. Jackson, *Nashville*; Hugh G. Kyle, *Rogersville*.

STATION STAFF.

Chas. W. Dabney, jr., PH. D., LL. D., <i>President of the College.*</i>	
Chas. F. Vanderford, <i>Sec. and Agr.</i>	S. M. Bain, B. A., <i>Asst. Bot.</i>
F. Lamson-Scribner, B. S., <i>Bot.</i>	C. A. Mooers, B. S., <i>Asst. Chem.</i>
R. L. Watts, B. AGR., <i>Hort.</i>	C. E. Chambliss, <i>Clerk and Lib.</i>
J. B. McBryde, B. A., C. E., <i>Chem.</i>	T. F. Peck, <i>Foreman Farm.</i>

TEXAS.

Texas Agricultural Experiment Station, College Station.

Department of the State Agricultural and Mechanical College of Texas.

GOVERNING BOARD.

A. J. Rose (*Pres.*), *Salado*; L. S. Ross (*Treas.*), *College Station*; John E. Hollingsworth, *Austin*; W. R. Cavitt, *Bryan*; J. D. Fields, *Manor*; John Adriance, *Columbia*.

* On leave.

STATION STAFF.

L. S. Ross, *President of the College.*J. H. Connell, M. Sc., *Dir.*Jas. Clayton, *Agr.*H. H. Harrington, M. Sc., *Chem.*M. Francis, D. V. M., *Vet.*R. H. Price, B. S., *Hort.*D. Adriance, M. S., *Met. and Assoc. Chem.*J. W. Carson, B. S., *Asst. Dir.*J. M. Carson, B. S., *Asst. Agr.*P. S. Tilson, M. S., *Asst. Chem.*W. H. Broderick, *Sten.*

UTAH.

Agricultural Experiment Station of Utah, Logan.

Department of the Agricultural College of Utah.

GOVERNING BOARD.

W. S. McCornick (*Pres.*), *Salt Lake City*; J. E. Hyde (*Sec.*), *Logan*; Allan M. Fleming (*Treas.*), *Logan*; J. B. Keeler, *Provo*; A. R. Heywood, *Ogden*; J. W. McNutt, *Ogden*; A. G. Barber, *Logan*; James T. Hammond, *Logan*; W. R. Stover, *Logan*.

STATION STAFF.

J. W. Sanborn, B. S., *President of the College and Director.*E. S. Richman, M. S. A., *Hort. and Ent.*R. W. Erwin, *Asst. Chem.*S. S. Twombly, B. S., D. V. S., *Consulting Vet.*A. A. Mills, B. S., *Farm Supt.*F. W. Brewer, M. D., *Biol.*S. Fortier, C. E., *Irrig. Engin.*James Dryden, *Clerk and Sten.*Allan M. Fleming, *Treas.*

VERMONT.

Vermont Agricultural Experiment Station, Burlington.

Department of University of Vermont and State Agricultural College.

GOVERNING BOARD.

Matthew Henry Buckham (*Pres.*), *Burlington*; E. J. Ormsbee, *Brandon*; Crosby Miller, *Pomfret*; G. S. Fassett, *Enosburg*; Cassius Peck, *Brookfield*.

STATION STAFF.

Matthew Henry Buckham, D. D., *President of the College.*J. L. Hills, B. S., *Dir. and Chem.*L. R. Jones, Ph. B., *Bot.*G. H. Perkins, Ph. D., *Ent.*F. A. Rich, V. S., *Vet.*A. G. Gulley, M. S., *Hort.*B. O. White, Ph. B., *Asst. Chem.*D. D. Howe, *Supt. Farm.*M. F. Donahue, *Dairyman.*Mary A. Benson, *Sten.*E. H. Powell, *Treas.*

VIRGINIA.

Virginia Agricultural and Mechanical College Experiment Station, Blacksburg.*

Department of Virginia Agricultural and Mechanical College.

GOVERNING BOARD.

C. E. Vawter, *Crozet*; J. M. Barton, *Kernstown*; H. L. Carter, *Richmond*; T. S. Fitzgerald, *North Danville*; John E. Massey, *Richmond*; Frank Payne, *Newport*; A. R. Venable, *Richmond*; J. Thompson Brown, *Brierfield*; D. M. Cloyd, *Dublin*.

* Express and freight address, *Christiansburg*.

STATION STAFF.

J. M. McBryde, PH. D., LL. D., *President of the College and Director.*
 W. B. Alwood, V. Dir., Hort., Ent., and Myc. R. J. Davidson, M. A., Chem.
 E. A. Smyth, jr., M. A., Biol. E. P. Niles, D. V. M., Vet.
 D. O. Nourse, B. S., Agr. T. L. Watson, M. S., Asst. Chem.
 John Gardner, Treas.

WASHINGTON.

Washington Agricultural Experiment Station, Pullman.

Department of Washington Agricultural College and School of Science.

GOVERNING BOARD.

Chas. R. Conner (*Pres.*), Spokane; T. R. Tannatt, Farmington; H. S. Blandford, Walla Walla; E. S. Ingraham, Seattle; J. W. Stearns, Tekoa.

STATION STAFF.

E. A. Bryan, M. A., *President of the College and Director.*
 E. R. Lake, M. S., Agr. and Hort. Elton Fulmer, M. A., Chem.
 C. V. Piper, B. S., Bot. and Ent. L. C. Read, Asst. Hort.
 Jno. B. Jameson, Foreman Farm.

WEST VIRGINIA.

West Virginia Agricultural Experiment Station.

Department of West Virginia University.

GOVERNING BOARD.

John A. Robinson, Patterson's Depot; J. B. Sommerville, Wheeling; Clarence L. Smith, Fairmont; J. S. Withers, Glenville; John Bassel, Clarksburg; J. M. Holswade, Spencer; J. H. Stewart, Raymond City; Wirt A. French, Princeton; M. J. Kester, Union; J. F. Brown, Charleston; Thomas J. Farnsworth, Buckhannon; Joseph Moreland, Morgantown; W. W. Brown, Kabletown.

STATION STAFF.

P. B. Reynolds, *President of the University.*
 John A. Myers, M. A., PH. D., Dir. Rudolf J. J. DeRoode, PH. D., Chem.
 F. Wm. Rane, M. S., Hort. and Microscopist. W. E. Rumsey, B. S., Asst. Ent.
 A. D. Hopkins, Ent. Susie V. Mayers, Sten. and Bookkeeper.
 D. D. Johnson, M. A., Agr. John I. Harvey, Treas.

WISCONSIN.

Agricultural Experiment Station of the University of Wisconsin, Madison.

Department of University of Wisconsin.

GOVERNING BOARD.

William P. Bartlett (*Pres.*) Eau Claire; E. F. Riley (*Sec.*), Madison; State Superintendent of Instruction, Madison; President of University, Madison; H. B. Dale, Oshkosh; Jno. Johnston, Milwaukee; Nicholas D. Fratt, Racine; H. W. Chynoweth, Madison; B. J. Stevens, Madison; Geo. H. Noyes, Milwaukee; Charles Keith, Reedsburg; Orlando E. Clark, Appleton; D. L. Plumer, Wausau; John W. Bashford, Hudson.

STATION STAFF.

Charles Kendall Adams, LL. D., <i>President of the University.</i>	
W. A. Henry, B. AGR., <i>Dir.</i>	F. W. Woll, M. S., <i>Asst. Chem.</i>
S. M. Babcock, PH. D., <i>Chem.</i>	H. L. Russell, PH. D., <i>Bact.</i>
F. H. King, <i>Physicist.</i>	J. W. Decker, B. AGR., <i>Dairyman.</i>
E. S. Goff, <i>Hort.</i>	Leslie H. Adams, <i>Farm Supt.</i>
J. A. Craig, B. S. A., <i>Animal Industry.</i>	Winona Merriek, <i>Clerk and Sten.</i>

WYOMING.

Wyoming Agricultural Experiment Station, Laramie.

Department of the University of Wyoming.

GOVERNING BOARD.

Stephen W. Downey (*Pres.*), *Laramie*; Grace R. Hebard (*Sec.*), *Cheyenne*; R. H. Homer (*Treas.*), *Laramie*; Augustine Kendall, *Rock Springs*; John D. Loucks, *Sheridan*; Wm. W. Burton, *Afton*; Ethelbert Talbot, *Laramie*; Charles L. Vagner, *Carbon*; A. W. Jones, *Casper*; Stephen T. Farewell, *Cheyenne*; A. A. Johnson, *Laramie*.

STATION STAFF.

A. A. Johnson, M. A., D. D., <i>President of the University and Director.</i>	
B. C. Buffum, M. S., <i>Hort.</i>	Jacob S. Meyer, <i>Supt. Substa., Lander.</i>
J. D. Conley, M. A., PH. D., <i>Physics.</i>	John D. Parker, <i>Supt. Substa., Saratoga.</i>
Aven Nelson, M. S., <i>Bot.</i>	Jno. F. Lewis, <i>Supt. Substa., Sheridan.</i>
F. J. Niswander, B. S., <i>Ent. and Supt. Farm.</i>	Thos. A. Dunn, <i>Supt. Substa., Sundance.</i>
E. E. Slosson, M. S., <i>Chem.</i>	Martin R. Johnston, <i>Supt. Substa., Wheatland.</i>
W. C. Knight, M. A., <i>Geol.</i>	Grace R. Hebard, M. A., PH. D., <i>Sec.</i>

LIST OF AGRICULTURAL SCHOOLS AND COLLEGES IN THE UNITED STATES, WITH COURSES OF STUDY AND BOARDS OF INSTRUCTION.

ALABAMA.

Agricultural and Mechanical College of Alabama, Auburn.

COURSES OF STUDY.

The courses of study are five. Three of these require four years each for completion, and lead to the degree of B. S.: Course in chemistry and agriculture, course in mechanics and engineering, and general course. The two remaining courses require two years each, and lead to a certificate: Two years' course in agriculture and two years' course in mechanic arts.

BOARD OF INSTRUCTION.

Wm. LeRoy Broun, M. A., LL. D., <i>Pres.</i> ;	B. H. Crenshaw, M. S., <i>Instr. Mech. Arts.</i>
<i>Physics and Astronomy.</i>	J. T. Anderson, Ph. D., <i>Asst. in Chem.</i>
O. D. Smith, M. A., <i>Math.</i>	A. St. C. Dunstan, M. E., C. E., <i>Instr.</i>
P. H. Mell, jr., M. E., Ph. D., <i>Natural History and Geol.</i>	<i>Physical Lab.</i>
J. H. Lane, C. E., M. A., <i>Civil Engin. and Drawing.</i>	R. E. Noble, M. S., <i>Asst. in Chem.</i>
C. C. Thach, M. A., <i>English and Polit. Economy.</i>	C. L. Hare, M. S., <i>Asst. in Chem.</i>
B. B. Ross, M. S., <i>General and Agr. Chem.</i>	L. W. Payne, jr., M. S., <i>Asst. Lib. and Sec.</i>
A. J. Bondurant, M. A., <i>Agr.</i>	R. J. Trammel, C. E., <i>Asst. Instr. Mech. Arts.</i>
J. H. Wills, Lieut. 21st Infantry, U. S. A., <i>Military Science.</i>	R. L. Bivins, B. S., <i>Asst. in Bot.</i>
J. J. Wilmore, M. E., <i>Dir. Lab.; Instr. Mech. Arts.</i>	M. R. Burton, B. S., <i>Asst. in Civil Engin.</i>
C. H. Ross, Ph. D., (<i>Adjunct</i>) <i>Modern Languages and English.</i>	C. W. Daugette, B. S., <i>Asst. in Agr.</i>
G. Petrie, M. A., Ph. D., <i>History and Latin.</i>	H. K. Miller, B. S., <i>Asst. in Chem.</i>
A. F. McKissick, M. A., <i>Elect. Engin.</i>	W. M. Riggs, B. S., <i>Asst. in English.</i>
C. A. Cary, D. V. M., <i>Vet. Science.</i>	N. B. Marks, B. S., <i>Asst. in Library.</i>
	A. L. Quaintance, <i>Asst. in Biol.</i>
	T. L. Kennedy, B. S., <i>Asst. in Math.</i>
	J. F. Webb, B. S., <i>Asst. in English and Math.</i>
	J. H. Holt, B. S., <i>Asst. in Mech. Arts.</i>

ARIZONA.

University of Arizona, Tucson.

COURSE OF STUDY.

The course of study in agriculture requires four years for completion, and leads to the degree of B. S.

BOARD OF INSTRUCTION.

T. B. Comstock, D. Sc., <i>Pres.</i> ; <i>Mining and Metallurgy.</i>	Edward M. Boggs, C. E., <i>Irrig. Engin.</i>
F. A. Gulley, M. S., <i>Agr.</i>	J. W. Toumey, B. S., <i>Biol.</i>
C. B. Collingwood, M. S., <i>Chem.</i>	H. J. Hall, <i>English.</i>

ARKANSAS.

Arkansas Industrial University, Fayetteville.

COURSES OF STUDY.

The University offers the following courses in the departments at Fayetteville: Three in engineering, leading to the degrees of B. M. E., B. C. E., and B. E. E.; four in science, leading to the degree of B. S., with one of the following subjects as a specialty: Chemistry, botany and zoölogy, horticulture and entomology, and geology; one in liberal arts, the classical leading to the degree of B. A.; four short courses without degree, students in which at the end of the sophomore year may change to one leading to one of the above degrees, viz, farmers', manual training, normal, and medical preparatory courses. In addition to the above, the medical department and the law department, both at Little Rock, have courses of study leading to the degrees of M. D. and B. L., respectively, and the Branch Normal College (colored) at Pine Bluff has normal and mechanical courses.

BOARD OF INSTRUCTION.

E. H. Murfee, M. A., LL. D., <i>Pres.</i> ; <i>Psychology and Ethics.</i>	W. E. Goldsborough, M. E., (<i>Adjunct</i>) <i>Elect. Engin.</i>
A. E. Menke, D. Sc., <i>Agr., Chem., and Physics.</i>	Jesse L. Cravens, B. L., <i>Instr. Elocution.</i>
Oliver C. Gray, M. A., LL. D., <i>Math., Logic, and Astronomy.</i>	J. B. Marcheselli, <i>Instr. Music.</i>
J. F. McNeill, B. S., <i>Biol. and Geol.</i>	Mrs. S. E. Meek, <i>Instr. Music.</i>
R. H. Willis, M. A., <i>English and Modern Languages.</i>	Sam Taff, <i>Instr. Wood Work.</i>
Chas. V. Kerr, Ph. M., M. E., <i>Mech. Arts and Engin.</i>	W. D. Ash, <i>Instr. Foundry and Forging.</i>
Chas. H. Leverett, M. A., <i>Ancient Languages and Literature.</i>	Mack Martin, B. M. E., <i>Instr. Machine Shop.</i>
Julius F. Howell, M. A., <i>History and Pedagogics.</i>	Mrs. A. M. Tyler, <i>Prin. Preparatory Dept.</i>
R. W. Dowdy, 1st Lieut. 17th Infantry, U. S. A., <i>Military Science and Tactics.</i>	G. A. Cole, jr., B. A., <i>Asst. in Preparatory Dept.</i>
J. J. Knoch, C. E., (<i>Adjunct</i>) <i>Civil Engin.</i>	Mary E. Washington, <i>Asst. in Preparatory Dept.</i>
W. B. Bentley, M. A., (<i>Adjunct</i>) <i>Chem. and Physics.</i>	Mrs. G. A. Cole, B. L., <i>Asst. in Preparatory Dept.</i>
Ella H. Carnall, Ph. M., (<i>Adjunct</i>) <i>English and Modern Languages.</i>	Naomi J. Williams, M. A., <i>Asst. in Preparatory Dept.</i>
Geo. W. Droke, M. A., (<i>Adjunct</i>) <i>Math.</i>	Mary Davis, B. A., <i>Asst. in Preparatory Dept.</i>
Seth E. Meek, Ph. D., (<i>Adjunct</i>) <i>Biol. and Geol.; Curator Museum.</i>	Julia A. Garside, <i>Lib.</i>
	Wm. F. Bates, <i>Foreman Farm.</i>
	J. M. Moore, <i>Asst. Foreman Farm.</i>
	V. H. Caywood, <i>Engin.</i>
	C. H. Chesebro, <i>Janitor.</i>

CALIFORNIA.

College of Agriculture of the University of California, Berkeley.

COURSE OF STUDY.

The course of study requires four years for completion and leads to the degree of B. S.

BOARD OF INSTRUCTION.

- | | |
|---|--|
| M. Kellogg, LL. D., <i>Pres.</i> ; <i>Latin Language and Literature.</i> | F. V. Paget, B. L., B. S., (<i>Assoc.</i>) <i>French and Spanish.</i> |
| I. Stringham, PH. D., <i>Dean</i> ; <i>Math.</i> | F. L. Winn, 1st Lieut. 12th Infantry, U. S. A., <i>Military Science and Tactics.</i> |
| E. W. Hilgard, PH. D., LL. D., <i>Agr. and Agr. Chem.</i> | W. J. Sharwood, <i>Instr. Chem.</i> |
| E. J. Wickson, M. A., (<i>Assoc.</i>) <i>Agr., Hort., and Ent.</i> | M. A. Howe, PH. B., <i>Instr. Cryptogamic Bot.</i> |
| R. H. Loughridge, PH. D., (<i>Asst.</i>) <i>Agr. Geol. and Agr. Chem.</i> | A. B. Pierce, M. A., <i>Instr. Math.</i> |
| E. L. Greene, PH. B., <i>Bot.</i> | F. G. Burgess, B. S., <i>Instr. Topographical and Free-hand Drawing.</i> |
| Wm. B. Rising, M. A., M. E., PH. D., <i>Chem.</i> | W. D. Armes, PH. B., <i>Instr. English.</i> |
| E. O'Neill, PH. B., (<i>Asst.</i>) <i>Chem.</i> | T. F. Sanford, B. A., <i>Instr. English.</i> |
| J. Le Conte, M. A., M. D., LL. D., <i>Geol. and Natural History.</i> | S. D. Huntington, B. A., <i>Instr. French.</i> |
| A. C. Lawson, M. A. PH. D., (<i>Assoc.</i>) <i>Min. and Geol.</i> | H. I. Randall, B. S., <i>Instr. Civil Engin.</i> |
| C. W. Woodworth, M. S., <i>Ent.</i> | J. Sutton, PH. B., <i>Recorder.</i> |
| G. C. Edwards, PH. B., (<i>Assoc.</i>) <i>Math.</i> | M. E. Jaffa, PH. B., <i>Instr. Agr.</i> |
| M. W. Haskell, PH. D., (<i>Asst.</i>) <i>Math.</i> | G. E. Colby, PH. B., <i>Instr. Vit.</i> |
| A. O. Leuschner, B. A., (<i>Asst.</i>) <i>Math.</i> | W. J. Raymond, B. S., <i>Instr. Physics.</i> |
| F. Slate, B. S., <i>Physics.</i> | E. R. Drew, B. S., <i>Instr. Physics.</i> |
| N. Whiting, PH. D., (<i>Assoc.</i>) <i>Physics.</i> | A. P. Hayne, PH. B., <i>Instr. Vit.</i> |
| W. E. Ritter, M. A., (<i>Asst.</i>) <i>Biol.</i> | C. L. Gilman, <i>Asst. in Chem.</i> |
| H. Kower, C. E., <i>Asst. Instr. Drawing.</i> | R. S. Norris, B. S., <i>Asst. in Chem.</i> |
| F. Soule, <i>Civil Engin. and Astronomy.</i> | V. Lenher, <i>Asst. in Chem.</i> |
| B. Moses, PH. D., <i>History and Polit. Economy.</i> | W. C. Blasdale, B. S., <i>Asst. in Chem.</i> |
| C. M. Gayley, B. A., <i>English Language and Literature.</i> | S. J. Holmes, B. S., <i>Asst. in Biol.</i> |
| C. B. Bradley, M. A., (<i>Assoc.</i>) <i>English Language and Literature.</i> | A. G. Van Gorder, <i>Asst. in Physics.</i> |
| A. F. Lange, PH. D., (<i>Asst.</i>) <i>English Language and Literature.</i> | W. L. Jepson, PH. B., <i>Asst. in Bot.</i> |
| A. Putzker, M. A., <i>German.</i> | F. H. Payne, M. D., <i>Dir. Physical Culture.</i> |
| J. H. Senger, PH. D., (<i>Asst.</i>) <i>German.</i> | Mary B. Ritter, M. D., <i>Woman Physician in Dept. Physical Culture.</i> |
| | W. E. Magee, <i>Instr. Physical Culture.</i> |
| | F. L. Ransome, B. S., <i>Fellow in Min.</i> |
| | L. T. Heugstler, M. A., <i>Fellow in Math.</i> |
| | C. S. H. Howard, <i>Fellow in French.</i> |
| | J. C. Rowell, B. A., <i>Lib.</i> |

COLORADO.

The State Agricultural College of Colorado, Fort Collins.

COURSES OF STUDY.

The courses of study are five, each requiring four years in addition to one year of preparatory work, and each leading to the degree of B. S.: The agricultural course, the mechanical course, the irrigation engineering course, the chemical course, and the ladies' course. Provision is made for post-graduate work, but no additional degree is granted.

BOARD OF INSTRUCTION.

- | | |
|--|---|
| Alston Ellis, M. A., PH. D., LL. D., <i>Pres.</i> ; | H. D. Humphrey, 2d Lieut. 20th Infantry, U. S. A., <i>Military Science and Tactics.</i> |
| J. W. Lawrence, B. S., <i>Mech. and Drawing.</i> | Celia M. Southworth, B. S., <i>Lib.</i> |
| Maud Bell, <i>History, Languages, and Literature.</i> | L. D. Crain, B. M. E., <i>Asst. in Mech. and Drawing.</i> |
| Wm. P. Headden, M. A., PH. D., <i>Chem. and Geol.</i> | J. D. Stannard, B. S., <i>Asst. in Physics and Engin.</i> |
| L. G. Carpenter, M. S., <i>Physics and Irrig. Engin.</i> | Chas. F. Baker, B. S., <i>Asst. in Zoöl. and Ent.</i> |
| C. S. Crandall, M. S., <i>Bot. and Hort.</i> | W. H. Goodall, B. L., <i>Elocution and Calisthenics.</i> |
| C. P. Gillette, M. S., <i>Zoöl. and Ent.</i> | Chas. J. Ryan, <i>Asst. in Chem.</i> |
| W. W. Cooke, B. S., M. A., <i>Agr.</i> | R. E. Trimble, B. S., <i>Asst. in Met.</i> |
| Grace Espey Patton, B. S., <i>English and Sten.</i> | M. J. Huffington, <i>Asst. in Hort.</i> |
| W. J. Meyers, B. S., <i>Math.</i> | L. M. Taylor, B. S., <i>Sten.</i> |
| D. W. Working, B. S., <i>Sec. Faculty.</i> | |

CONNECTICUT.

Sheffield Scientific School of Yale University, New Haven.

COURSES OF STUDY.

Courses of instruction occupying three years and leading to the degree of Ph. B. are arranged to suit the requirements of students. The first year's work is the same for all; for the last two years the instruction is chiefly arranged in special courses. Those most distinctly marked out are the following: In chemistry, in civil engineering, in mechanical engineering, in agriculture, in natural history, in biology preparatory to medical studies, in studies preparatory to mining and metallurgy, and in select studies preparatory to other higher studies. Under certain conditions the degrees of civil engineer and mechanical (or dynamical) engineer are conferred on bachelors of philosophy who have taken the first degree in engineering and who pursue a higher course under the direction of the governing board of the school for at least two years.

BOARD OF INSTRUCTION.

- | | |
|--|---|
| Timothy Dwight, D. D., LL. D., <i>Pres.</i> | A. Guyot Cameron, PH. D., (<i>Asst.</i>) <i>French.</i> |
| Geo. J. Brush, LL. D., <i>Dir.</i> ; <i>Min.</i> | A. J. Wakeman, PH. B., <i>Instr. Anal. Chem.</i> |
| W. D. Whitney, PH. D., LL. D., <i>Comparative Philology.</i> | W. A. Setchell, PH. D., <i>Instr. Biol.</i> |
| S. W. Johnson, M. A., <i>Theoretical and Agr. Chem.</i> | R. N. Corwin, B. A., <i>Instr. German.</i> |
| W. H. Brewer, PH. D., <i>Agr.</i> | P. F. Smith, PH. D., <i>Instr. Math.</i> |
| John E. Clark, M. A., <i>Math.</i> | E. H. Lockwood, M. E., <i>Instr. Drawing and Mechanism.</i> |
| D. C. Eaton, M. A., <i>Bot.</i> | Langdon Frothingham, M. D. V., <i>Asst. in Vet. Science and Bacteriology.</i> |
| C. B. Richards, M. A., <i>Mech. Engin.</i> | H. A. Smith., B. A., <i>Instr. English.</i> |
| T. R. Lounsbury, LL. D., <i>English.</i> | W. I. Lowe, B. A., <i>Instr. History.</i> |
| A. E. Verrill, M. A., <i>Zoöl.</i> | F. R. Rich. PH. B., <i>Asst. in German.</i> |
| S. I. Smith, M. A., <i>Comparative Anatomy.</i> | J. C. Tracey, C. E., <i>Asst. in Civil Engin.</i> |
| W. G. Mixter, M. A., <i>Chem.</i> | C. M. Williams, B. A., PH. B., <i>Asst. in Physiol. Chem.</i> |
| A. Jay DuBois, C. E., PH. D., <i>Civil Engin.</i> | G. P. Starkweather, PH. B., <i>Asst. in Drawing.</i> |
| C. S. Hastings, PH. D., <i>Physics.</i> | L. B. Mendel, PH. D., <i>Asst. in Physiol. Chem.</i> |
| H. W. Farnam, M. A., R. P. D., <i>Polit. Economy.</i> | |
| R. H. Chittenden, PH. D., <i>Physiol. Chem.</i> | |

S. L. Penfield, PH. B., <i>Min.</i>	H. A. Bumstead, B. A., <i>Instr. Physics.</i>
H. L. Wells, PH. B., <i>Anal. Chem. and Metallurgy.</i>	G. F. Campbell, PH. B., <i>Instr. Chem.</i>
A. S. Wheeler, M. A., <i>Instr. German.</i>	W. R. Coe, PH. B., <i>Asst. in Biol.</i>
Mark Bailey, M. A., <i>Instr. Elocution.</i>	P. T. Walden, PH. B., <i>Asst. in Anal. Chem.</i>
John H. Niemeyer, M. A., <i>Drawing.</i>	M. A. Pond, PH. B., <i>Asst. in Drawing.</i>
W. H. Bishop, B. A., <i>Instr. French and Spanish.</i>	F. M. Adams, PH. B., <i>Asst. in Physics.</i>
T. W. Mather, M. E., <i>Instr. Mech. Engin.</i>	C. C. Wilson, B. A., <i>Asst. in Mechanism.</i>
J. S. Pettit, Capt., U. S. A., <i>Military Science.</i>	J. W. Coe, PH. B., <i>Asst. in Chem.</i>
S. E. Barney, C. E., <i>Instr. Math. and Civil Engin.</i>	W. A. Granville, PH. B., <i>Asst. in Math.</i>
L. V. Pirsson, PH. B., <i>Instr. Geol. and Lithology.</i>	W. T. H. Howe, PH. B., <i>Asst. in Chem.</i>
F. E. Beach, PH. D., <i>Asst. in Physics.</i>	C. A. Ingersoll, PH. B., <i>Asst. in Descriptive Geometry.</i>
	Paul Klimpe, B. A., <i>Instr. German.</i>
	J. H. Pratt, PH. B., <i>Asst. in Chem.</i>
	A. H. Stevens, PH. B., <i>Asst. in Machine Designing.</i>

Storrs Agricultural College, Mansfield.

COURSE OF STUDY.

The course of study requires two or four years for completion and in the latter case leads to a degree.

BOARD OF INSTRUCTION.

B. F. Koons, PH. D., <i>Pres.</i>	Lottie J. Short, <i>Domestic Science.</i>
A. B. Peebles, B. S., <i>Chem. and Math.</i>	H. E. Woodbury, B. S., <i>Hort.</i>
C. S. Phelps, B. S., <i>Agr.</i>	C. A. Davis, <i>Instr. Wood and Iron Work.</i>
Geo. A. Waterman, D. V. M., <i>Vet. Science.</i>	L. J. Barber, <i>Instr. Mech. and Engin.</i>
	Mary E. Wilson, <i>Housekeeper.</i>

DELAWARE.

Delaware College, Newark.

COURSES OF STUDY.

The courses of study are seven, and require four years each for completion: The classical and the Latin scientific courses, each leading to the degree of B. A.; the course in modern languages and science, leading to the degree of B. S.; the courses in engineering, leading to the degrees of C. E., M. E., and E. E.; and the agricultural course, leading to the degree of B. Agr. There are also a two years' course and a short winter course of thirteen weeks in agriculture.

BOARD OF INSTRUCTION.

A. N. Raub, PH. D., <i>Pres.; English, Mental, Moral and Polit. Science.</i>	M. H. Beckwith, <i>Hort. and Ent.</i>
T. R. Wolf, PH. D., <i>Chem., Min. and Sanitary Science.</i>	C. L. Penny, M. A., <i>German.</i>
F. D. Chester, M. S., <i>Bot. and Geol.</i>	F. A. Weihe, M. E., <i>Mech. and Elect. Engin.</i>
G. A. Harter, PH. D., <i>Math. and Physics.</i>	F. H. Robinson, C. E., <i>Civil Engin.</i>
C. S. Conwell, M. A., <i>Ancient and Modern Languages.</i>	W. H. Bishop, B. S., <i>Agr.</i>
	H. P. Eves, D. V. S., <i>Vet. Science.</i>
	Lieut. J. H. Frier, <i>Military Science and Tactics.</i>

State College for Colored Students, Dover.

COURSES OF STUDY.

There are five courses of study: Classics, science, agriculture, engineering, and chemistry.

BOARD OF INSTRUCTION.

Wesley Webb, M. S., *Pres.*S. L. Conwell, B. A., *Asst.*L. D. Hileland, *Instr.*

FLORIDA.

Florida State Agricultural and Mechanical College, *Lake City.*

COURSES OF STUDY.

Besides a preparatory department, there are three collegiate courses of study, each requiring four years for completion: The classical course, leading to the degree of B. A.; the agricultural course, leading to the degree of B. S.; and the mechanical course, leading to the degree of M. E.

BOARD OF INSTRUCTION.

O. Clute, M. S., LL. D., *Pres.; Agr.*A. A. Persons, B. S., *Agr. Chem.*W. F. Yocum, M. A.; *Mental and Moral Philosophy.*H. C. Powers, *Manual Training and Drawing.*J. J. Earle, B. A., *Physics and Chem.*Jno. B. Parkinson, *Penmanship and Book-keeping.*H. P. Baya, *Math. and Military Science and Tactics.*Bettie C. DeSha, *Sten., Typewriting and Telegraphy.*J. M. Stuart, B. A., *English and Literature.*E. J. Bending, *Asst. in Wood Shops.*C. V. Waugh, *Latin and History.*J. C. Martin, jr., M. A., *In Charge Preparatory Dept.*J. N. Whitner, M. A., *Pomology and Hort.*P. H. Rolfs, M. S., *Natural Science, Ent. and Bot.*J. F. Appell, M. D., *Physician.*Florida State Normal School, *Tallahassee.*

COURSES OF STUDY.

The courses of study are four: Preparatory, normal, manual training, and agricultural.

BOARD OF INSTRUCTION.

T. DeS. Tucker, M. A., *Pres.*Alexander Cuppage, *Agr.*T. V. Gibbs, *Math.*T. W. Talley, M. A., *Natural Science.*D. W. Onley, *Manual Training and Chem.*M. L. Anderson, *Domestic Economy.*P. Van Weller, *English.*Frederica F. Jones, M. A., *Prin. Preparatory Dept.*C. B. Tucker, *Dairying.*

GEORGIA.

Georgia State College of Agriculture and Mechanic Arts, *Athens.*

COURSES OF STUDY.

There are two courses of study, requiring four years each for completion and leading to the degrees of B. S. and B. E.; one three years' course, leading to the degree of B. Agr.; post-graduate courses of one year each, leading to degrees of M. S., C. E., and M. Agr.; special courses in chemistry, mining and metallurgy, in agriculture, in electrical engineering, and in building and architecture, in which certificates of attainment are given. There is also a short winter course in agriculture, comprising instruction in the English branches, agriculture and dairying.

BOARD OF INSTRUCTION.

H. C. White, PH. D., <i>Pres.; Chem.</i>	J. H. T. McPherson, PH. D., <i>History.</i>
L. H. Charbonnier, M. A., PH. D., <i>Physics.</i>	J. B. Hunnicutt, B. A., <i>Agr.</i>
C. P. Willcox, M. A., LL. D., <i>Modern Languages.</i>	C. M. Snelling, B. S., <i>Instr. Math.; Com-mandant.</i>
B. F. Riley, M. A., <i>English.</i>	C. H. Herty, PH. D., <i>Instr. Anal. Chem.</i>
D. C. Barrow, jr., C. M. E., <i>Math.</i>	Jesse Coates, B. E., <i>Instr. Physics.</i>
C. M. Strahan, C. M. E., <i>Engin.</i>	O. E. Sheffield, B. E., <i>Instr. Drawing.</i>
John P. Campbell, B. A., PH. D., <i>Biol.</i>	Jno. Morris, M. A., <i>Instr. English.</i>
H. J. Wing, <i>Instr. Dairying.</i>	

IDAHO.

College of Agriculture of the University of Idaho, Moscow.

COURSE OF STUDY.

The course of study in agriculture requires four years for completion.

BOARD OF INSTRUCTION.

F. B. Gault, M. S., <i>Pres.</i>	Chas. W. McCurdy, D. Sc., <i>Chem. and Hort.</i>
John E. Ostrander, C. E., M. A., <i>Civil En-gin. and Mech. Arts.</i>	Annette Bowman, <i>Instr. Industrial Draw-ing and History.</i>
Robert Milliken, <i>Agr. and Hort.</i>	N. G. Brown, <i>Instr. English Branches.</i>

ILLINOIS.

College of Agriculture of the University of Illinois, Champaign.

COURSES OF STUDY.

The courses of study are three: The agricultural course, requiring four years for completion and leading to the degree of B. S.; the junior course in agriculture, requiring two years for completion, and leading to no degree; and a special course for farmers beginning in January and continuing eleven weeks.

BOARD OF INSTRUCTION.

T. J. Burrill, M. A., PH. D., <i>Acting Regent; Bot. and Hort.</i>	G. W. Myers, M. L., (<i>Asst.</i>) <i>Math.</i>
J. M. Gregory, LL. D., (<i>Emeritus</i>) <i>Polit. Economy.</i>	Katharine Merrill, (<i>Asst.</i>) <i>English Lan-guage and Literature.</i>
G. E. Morrow, M. A., <i>Dean; Agr.</i>	David Kinley, PH. D., (<i>Asst.</i>) <i>Polit. Econ-omy.</i>
S. W. Shattuck, M. A., C. E.; <i>Math.</i>	E. J. Townsend, PH. M., (<i>Asst.</i>) <i>Math.</i>
J. D. Crawford, M. A., <i>History.</i>	G. P. Clinton, B. S., <i>Asst. in Bot.</i>
S. A. Forbes, PH. D., <i>Zoöl. and Ent.</i>	T. A. Clark, B. L., <i>Instr. English.</i>
C. W. Rolfe, M. S., <i>Geol.</i>	F. D. Gardner, B. S., <i>Instr. Agr.</i>
D. McIntosh, V. S., <i>Vet. Science.</i>	A. M. Barber, M. S., <i>Asst. in Bot.</i>
A. W. Palmer, D. Sc., <i>Chem.</i>	A. H. White, B. A., <i>Asst. in Chem.</i>
E. R. Hills, Capt. 5th Artillery, U. S. A., <i>Military Science.</i>	Frank Smith, M. A., <i>Asst. in Zoöl.</i>
S. W. Parr, M. S., <i>Anal. Chem.</i>	W. D. Gibbs, B. S., <i>Asst. in Agr.</i>
D. K. Dodge, PH. D., <i>English Language and Literature.</i>	C. Van M. Millar, B. S., <i>Asst. in Chem.</i>

INDIANA.

School of Agriculture, Horticulture, and Veterinary Science of Purdue University, La Fayette.

COURSE OF STUDY.

The course of study requires four years for completion and leads to the degree of B. S.

BOARD OF INSTRUCTION.

- | | |
|---|--|
| Jas. H. Smart, M. A., LL. D., <i>Pres.</i> | Carolyn Gerrish, <i>Instr. Elocution and English.</i> |
| Wm. F. M. Goss, M. S., <i>Experimental Engin.</i> | Abby Lytle, <i>Instr. Industrial Art.</i> |
| Moses C. Stevens, M. A., <i>Higher Math.</i> | Geo. Spitzer, PH. G., <i>Instr. Pharmacy.</i> |
| Oscar J. Craig, M. A., PH. D., <i>Polit. Economy and History.</i> | James D. Hoffman, B. M. E., <i>Instr. Wood Shop.</i> |
| James Troop, M. S., <i>Hort. and Ent.</i> | Julius Stuermer, PH. G., <i>Instr. Materia Medica.</i> |
| Arthur L. Green, PH. C., <i>Dean School of Pharmacy.</i> | Chas. D. Peterson, B. C. E., <i>Instr. Mech. Drawing.</i> |
| Henry A. Huston, M. A., A. C., <i>Agr. Chem.</i> | Anna E. Baker, M. S., <i>Instr. Wood Carving and Model Drawing.</i> |
| Mrs. Emma Mont. McRae, <i>Lady Prin.; English Literature.</i> | Glasgow A. Read, <i>Instr. Foundry and Forging.</i> |
| Joseph C. Arthur, D. SC., <i>Vegetable Physiol. and Pathology.</i> | Stephen G. Wright, B. S., <i>Asst. in Vegetable Pathology and Physiol.</i> |
| Alfred E. Phillips, C. E., M. A., <i>Civil Engin.</i> | Richard A. Smart, B. M. E., <i>Asst. in Mech. Lab.</i> |
| Stanley Coulter, M. A., PH. D., <i>Biol.</i> | Wm. H. Test, B. S., <i>Asst. in Chem.</i> |
| Anna Von Holland, <i>Modern Languages.</i> | Katherine E. Golden, M. S., <i>Asst. in Biol.</i> |
| W. C. Latta, M. S., <i>Agr.</i> | Frank W. Brady, B. M. E., <i>Asst. in Elect.</i> |
| Erastus Test, M. A., M. D., <i>Prin. Preparatory Dept.</i> | Geo. R. Ives, B. S., <i>Asst. in Agr.</i> |
| Winthrop E. Stone, M. A., PH. D., <i>Organic and Inorganic Chem.; Dir. Chem. Lab.</i> | Edward C. Off, B. M. E., <i>Asst. in Engin.</i> |
| M. J. Golden, <i>Practical Mech.</i> | Robert D. Hawkins, B. M. E., <i>Asst. in Wood Shop.</i> |
| Chas. S. Plumb, B. S., <i>Agr. Science.</i> | John E. Kolb, B. M. E., <i>Asst. in Foundry and Forging.</i> |
| John J. Flather, PH. B., M. M. E., <i>Mech. Engin.</i> | Robert S. Moore, B. M. E., <i>Asst. in Machine Work.</i> |
| Thos. G. Alford, M. A., <i>Math.</i> | John D. Thomson, B. M. E., <i>Asst. in Mech. Drawing.</i> |
| Alfred M. Amadon, M. A., <i>Math.</i> | E. H. Neff, M. E., <i>Asst. in Machine Design.</i> |
| W. K. Hatt, B. A., C. E., (<i>Assoc.</i>) <i>Civil Engin.</i> | Leonard D. Worden, PH. G., <i>Asst. in Pharmacy.</i> |
| Harold B. Smith, M. E., <i>Elect. Engin.</i> | Benj. M. Hoak, <i>Asst. in Pharmacy.</i> |
| A. W. Duff, M. A., B. SC., <i>Physics and Theory of Elect.</i> | M. D. Strout, <i>Asst. in Mech. Lab.</i> |
| A. W. Bitting, B. S., <i>Vet. Science.</i> | Elizabeth Day Swan, <i>Lib.</i> |
| Walter Jones, PH. D., <i>Anal. Chem.</i> | |
| David D. Johnson, 1st Lieut. 5th Artillery, U. S. A., <i>Military Science and Tactics; Asst. in Math.</i> | |
| Wm. P. Turner, <i>Instr. Machine Work.</i> | |

IOWA.

Iowa State College of Agriculture and Mechanic Arts, Ames.

COURSES OF STUDY.

The courses of study are eight: The course in agriculture, leading to the degree of B. Agr.; the course in veterinary science, leading to the degree of D. V. M.; the course in mechanical engineering, leading to the degree of B. M. E.; the course in civil engineering, leading to the degree of B. C. E.; the course in electrical engineering, leading to the degree of B. E. E.; the course in mining engineering, leading to the degree of B. M. E.; the course in sciences as related to the industries, leading to the degree of B. S., and the course for ladies, leading to the degree of B. L.

The veterinary course requires three years for completion, each of the others, four years. There are also a two years' course and a short winter course in agriculture and dairying.

BOARD OF INSTRUCTION.

W. M. Beardshear, M. A., LL. D., <i>Pres.</i> ;	C. F. Curtiss, B. S. A., <i>Agr.</i>
<i>Psychology and Ethics.</i>	W. B. Niles, D. V. M., <i>Vet. Science.</i>
M. Stalker, M. Sc., V. S., <i>Vet. Science.</i>	W. H. Meeker, M. E., <i>Mech. Engin.</i>
J. L. Budd, M. H., <i>Hort.</i>	Marie L. Chambers, <i>Elocution; Dir. Music.</i>
E. W. Stanton, M. Sc., <i>Math. and Economic Science.</i>	N. E. Hansen, B. Sc., <i>Hort.</i>
I. W. Smith, B. Sc., M. D., <i>Pathology, Histology, Therapeutics, and Comparative Anatomy.</i>	H. C. Wallace, B. Agr., <i>Dairying.</i>
J. R. Lincoln, <i>Military Science and Tactics; Mining Engin.</i>	S. W. Beyer, B. Sc., <i>Geol. and Zoöl.</i>
A. A. Bennett, M. Sc., <i>Chem.</i>	Louis B. Spinney, B. M. E., <i>Mech. and Elect. Engin.</i>
Herbert Osborn, M. Sc., <i>Zoöl. and Ent.</i>	T. Lennox, <i>Instr. Machine Shop.</i>
W. S. Franklin, M. Sc., <i>Physics and Elect. Engin.</i>	Minnie Roberts, B. L., <i>Asst. in Math.</i>
A. C. Barrows, M. A., D. D., <i>English Literature and History.</i>	Leo Thurlimann, B. Sc., <i>Asst. in Chem.</i>
L. H. Pammel, B. Agr., <i>Bot.</i>	Emma Boyd, B. L., <i>Asst. in Chem.</i>
Mrs. Eliza Owens, <i>Domestic Economy.</i>	Julia A. Wentch, B. L., <i>Asst. in Math.</i>
James Wilson, <i>Agr.</i>	F. C. Stewart, B. Sc., <i>Asst. in Bot.</i>
G. E. Patrick, M. Sc., <i>Agr. Chem.</i>	Jerry Replogle, D. V. M., <i>House Surgeon.</i>
A. Marston, C. E., <i>Civil Engin.</i>	Elmina Wilson, B. C. E., <i>Asst. in Civil Engin.</i>
Margaret Doolittle, B. A., <i>English, Latin, and Rhetoric.</i>	F. A. Leighton, <i>Instr. Dairying.</i>
G. W. Bissell, M. E., <i>Mech. Engin.</i>	Flora Wilson, B. L., <i>Lib.</i>
Celia Ford, <i>Preceptress; French and German.</i>	H. Nordstrum, <i>Instr. Carpentry.</i>
D. A. Kent, B. Sc., <i>Agr.</i>	W. W. Clark, <i>Instr. Blacksmithing.</i>
	Genevieve Westermann, <i>Instr. Piano and Organ.</i>
	Carrie Scott, <i>Instr. Violin and Theory.</i>
	A. B. Morse, D. V. S., M. D. (<i>Des Moines</i>), <i>Non-resident Lecturer on Vet. Science.</i>

KANSAS.

Kansas State Agricultural College, Manhattan.

COURSES OF STUDY.

The regular course of study requires four years for completion and leads to the degree of B. S. Special and post-graduate courses are also provided. The degree of M. S. is given upon post-graduate study with satisfactory evidence of proficiency, after three years, in science and industrial arts.

BOARD OF INSTRUCTION.

- | | |
|---|--|
| Geo. T. Fairchild, LL. D., <i>Pres.; Logic and Philosophy.</i> | C. C. Georgeson, M. S., <i>Agr.; Supt. Farm.</i> |
| G. H. Failyer, M. S., <i>Chem. and Min.</i> | E. B. Bolton, Capt. 23d Infantry, U. S. A., <i>Military Science and Tactics.</i> |
| E. A. Popenoe, M. A., <i>Hort. and Ent.</i> | E. R. Nichols, M. A., <i>Physics.</i> |
| D. E. Lantz, M. S., <i>Lib.; Math.</i> | N. S. Mayo, M. S., D. V. S., <i>Physiol. and Vet. Science.</i> |
| J. D. Walters, M. S., <i>Industrial Art and Designing.</i> | J. T. Willard, M. S., <i>Chem.</i> |
| I. D. Graham, M. A., <i>Sec.; Instr. Book-keeping.</i> | A. S. Hitchcock, M. S., <i>Bot.</i> |
| O. E. Olin, <i>English Language and Literature.</i> | S. C. Mason, M. S., <i>Hort.</i> |
| Mrs. Nellie S. Kedzie, M. S., <i>Household Economy and Hygiene.</i> | Josephine Harper, <i>Instr. Math.</i> |
| Mrs. Elida E. Winchip, <i>Supt. Sewing.</i> | Alice Rupp, <i>Instr. English.</i> |
| O. P. Hood, B. S., <i>Mech. and Engin.; Supt. Shops.</i> | H. M. Jones, B. A., <i>Instr. Rhetoricals.</i> |
| A. B. Brown, M. A., <i>Music.</i> | C. M. Breese, M. S., <i>Asst. in Chem.</i> |
| J. S. C. Thompson, <i>Supt. Printing.</i> | Julia R. Pearce, B. S., <i>Asst. Lib.</i> |
| F. H. White, M. A., <i>History and Polit. Science.</i> | Bessie B. Little, B. S., <i>Asst. in Sewing.</i> |
| | Wm. Baxter, <i>Foreman Greenhouse.</i> |
| | W. L. House, <i>Foreman Carpenter Shop.</i> |
| | E. Harrold, <i>Foreman Iron Shop.</i> |

KENTUCKY.

Agricultural and Mechanical College of Kentucky, Lexington.

COURSES OF STUDY.

The regular courses of study are six, each requiring four years for completion: The agricultural course, leading to the degree of B. S.; the scientific course, leading to the same degree; the classical course, leading to the degree of B. A.; the mechanical engineering course, leading to the degree of M. E.; the civil engineering course, leading to the degree of C. E.; and the normal course, leading to the degree of B. Ped. Certificates of proficiency are given to those who do not complete a course undertaken.

BOARD OF INSTRUCTION.

- | | |
|--|--|
| J. K. Patterson, PH. D., <i>Pres.; Metaphysics and Civil History.</i> | F. Paul Anderson, B. M. E., <i>Mech. Engin.</i> |
| J. Shackelford, M. A., <i>V. Pres.; English Language and Literature.</i> | C. D. Clay, 1st Lieut., U. S. A., <i>Military Science.</i> |
| Robert Peter, M. D. (<i>Emeritus</i>), <i>Chem.</i> | J. W. Pryor, M. D., <i>Anatomy and Physiol.</i> |
| J. G. White, M. A., <i>Math. and Astronomy.</i> | W. K. Patterson, <i>Prin. Academy.</i> |
| F. M. Helveti, M. A., <i>French and German Languages and Literature.</i> | J. L. Logan, B. A., <i>Asst. in Academy.</i> |
| J. H. Neville, M. A., <i>Latin and Greek Languages and Literature.</i> | J. W. Newman, B. S., <i>Asst. in Normal Dept.</i> |
| J. H. Kastle, PH. D., <i>Chem.</i> | R. L. Blanton, M. LIT., <i>Asst. in Greek and Latin.</i> |
| R. N. Roark, B. A., <i>Prin. Normal Dept.</i> | J. M. Davis, B. A., B. S., <i>Asst. in Academy.</i> |
| H. Garman, <i>Zoöl. and Ent.</i> | V. E. Muncey, B. S., <i>Asst. in Academy.</i> |
| C. W. Mathews, B. S., <i>Agr., Hort. and Bot.</i> | J. H. Wells, B. M. E., <i>Asst. in Mech. Engin.</i> |
| J. P. Nelson, M. A., <i>Civil Engin. and Physics.</i> | J. R. Johnson, B. M. E., <i>Asst. in Mech. Engin.</i> |
| M. L. Pence, M. S., <i>asst. Civil Engin. and Physics.</i> | Mrs. Lucy B. Blackburn, <i>Asst. in Academy.</i> |
| | James Murray, <i>Practical Hort.</i> |

State Normal School, Frankfort.

COURSES OF STUDY.

There are four courses of study: Normal course, agricultural course, mechanical course, and a course in domestic economy.

BOARD OF INSTRUCTION.

J. H. Jackson, M. A., *Prin.*
M. A. Davis, *Teacher.*
Celia A. Hathaway, *Teacher.*

Ida Joyce Jackson, *Teacher.*
Lizzie E. Green, *Teacher.*
J. S. Hathaway, M. A., *Teacher.*

LOUISIANA.**Louisiana State University and Agricultural and Mechanical College, Baton Rouge.**

COURSES OF STUDY.

The regular courses of study are three, each requiring four years for completion: The course in agriculture, the course in mechanics and civil engineering, and the literary course, the first two leading to the degree of B. S., the last to the degree of B. A. A preparatory department and a two years' commercial course are also provided.

BOARD OF INSTRUCTION.

J. W. Nicholson, M. A., LL. D., <i>Pres.; Math.</i>	C. E. Ives, M. A., <i>Prin. Preparatory Dept.</i>
S. B. Staples, B. S., D. V. S., <i>Vet. Science.</i>	D. N. Barrow, B. S., (<i>Asst.</i>) <i>Agr.</i>
W. H. Goodale, B. A., <i>Civics and Philosophy.</i>	B. F. Hoffman, M. A., M. L., (<i>Adjunct</i>) <i>Languages.</i>
E. S. Benton, 1st Lieut. 3d Artillery, U. S. A., <i>Military Science and Tactics.</i>	C. A. Smith, B. A. PH. D., <i>English and English Literature.</i>
F. H. Burnette, <i>Instr. Hort.</i>	W. W. Clendenin, M. S., M. A., <i>Bot., Myc. and Geol.</i>
H. A. Morgan, B. S. A., <i>Ent. and Zoöl.</i>	C. E. Coates, M. A., PH. D., <i>Chem. and Min.</i>
J. H. Randolph, jr., C. E., <i>Drawing and Mech.</i>	T. W. Atkinson, B. S., C. E., <i>Instr. Preparatory Dept.</i>
E. L. Scott, M. A., <i>Languages.</i>	C. K. Thompson, B. S., C. E., <i>Instr. Preparatory Dept.</i>
H. Skolfield, <i>Instr. Bookkeeping.</i>	A. C. Read, M. A., <i>Instr. Preparatory Dept.</i>
Wm. C. Stubbs, PH. D., <i>Agr.</i>	
W. D. Taylor, C. E., <i>Physics and Civil Engin.</i>	

Southern University and Agricultural and Mechanical College, New Orleans

COURSE OF STUDY.

The courses in agriculture require two and four years for completion and lead to the degree of B. S.

BOARD OF INSTRUCTION.

H. A. Hill, <i>Pres.; Math.</i>	A. B. Kennedy, <i>Economic Science.</i>
Hugh Jamieson, <i>Agr.</i>	V. L. Roy, <i>Chem. and Physics.</i>
William Seymour, <i>Mech.</i>	W. J. Nickerson, <i>Music.</i>
L. M. Martinet, <i>Bot.</i>	Chas. Roos, <i>English.</i>
S. M. Angell, M. D., <i>Anatomy and Vegetable Pathology.</i>	E. E. Duncan, <i>Matron.</i>

MAINE.

The Maine State College, Orono.

COURSES OF STUDY.

Five full courses of study are provided, each requiring four years for completion: A course in agriculture, a course in chemistry, and a course in science and literature, each leading to the degree of B. S.; a course in civil engineering, leading to the degree of B. C. E.; and a course in mechanical engineering, leading to the degree of B. M. E. Special courses are also provided, leading to certificates.

BOARD OF INSTRUCTION.

Abram W. Harris, M. A., Ph. D., <i>Pres.</i>	Fred P. Briggs, B. S., <i>Natural History.</i>
Geo. H. Hamlin, C. E., <i>Civil Engin.</i>	Nathan C. Grover, B. C. E., <i>Civil Engin.</i>
Alfred B. Aubert, M. S., <i>Chem.</i>	Harriet C. Fernald, M. S., <i>Lib.</i>
Allen E. Rogers, M. A., <i>History, Logic and Polit. Economy.</i>	Welton M. Munson, B. S., <i>Hort. and Landscape Gardening.</i>
Walter Balentine, M. S., <i>Agr.</i>	Horace M. Estabrooke, M. S., M. A., <i>Rhetoric and Modern Languages.</i>
Walter Flint, M. E., <i>Mech. Engin.</i>	James S. Stevens, M. S., Ph. D., <i>Physics.</i>
Francis L. Harvey, M. S., Ph. D., <i>Natural History.</i>	Mark L. Hersey, M. A., Lieut. 9th Infantry, U. S. A., <i>Military Science and Tactics.</i>
James N. Hart, C. E., <i>Math. and Astronomy.</i>	Gilbert M. Gowell, <i>Animal Husbandry.</i>
Howard S. Webb, B. M. E., <i>Shop Work; Sec. and Registrar.</i>	David W. Colby, B. S., <i>Chem.</i>

MARYLAND.

Maryland Agricultural College, College Park.

COURSE OF STUDY.

The course of study requires four years and leads to the degree of B. S.

BOARD OF INSTRUCTION.

R. W. Silvester, <i>Pres.; Math.</i>	Thos. H. Spence, <i>Latin and French.</i>
H. B. McDonnell, M. D., <i>Chem.</i>	W. L. Taliaferro, <i>Agr.</i>
W. H. Zimmerman, M. A., <i>Physics; Instr. German.</i>	H. M. Strickler, <i>Physical Culture.</i>
R. H. Alvey, jr., B. A., <i>English.</i>	H. C. Sherman, B. S., <i>Asst. in Chem.</i>
J. H. Grisard, 2d Lieut., U. S. A., <i>Military Science and Tactics, Math. and Drawing.</i>	H. S. Harrison, <i>Prin. Preparatory Dept.</i>
Jas. S. Robinson, <i>Bot. and Hort.</i>	J. R. Owens, M. D., <i>Registrar; Sec. and Treas. Faculty.</i>
M. P. Scott, <i>Zoöl. and Comparative Anatomy.</i>	C. E. Straughn, <i>Instr. Woodwork.</i>
	T. P. Engle, <i>Instr. Forging and Smithing.</i>

MASSACHUSETTS.

Massachusetts Agricultural College, Amherst.

COURSE OF STUDY.

The course of study requires four years and leads to the degree of B. S.

BOARD OF INSTRUCTION.

H. H. Goodell, M. A., LL. D., <i>Pres.</i> ; <i>Modern Languages and English Literature.</i>	W. M. Dickinson, 1st Lieut. 17th Infantry, U. S. A., <i>Military Science and Tactics.</i>
Levi Stockbridge, <i>Agr.</i>	G. F. Mills, M. A., <i>English.</i>
C. A. Goessmann, PH. D., LL. D., <i>Chem.</i>	R. W. Lyman, LL. B., <i>Lecturer on Farm Law.</i>
S. T. Maynard, B. S., <i>Bot. and Hort.</i>	J. B. Paige, V. S., <i>Vet. Science.</i>
C. D. Warner, B. S., <i>Math. and Physics.</i>	E. R. Flint, PH. D., <i>Asst. in Chem.</i>
Charles Wellington, PH. D., (<i>Assoc.</i>) <i>Chem.</i>	G. E. Stone, PH. D., <i>Asst. in Bot.</i>
C. H. Fernald, PH. D., <i>Zoöl.</i>	A. C. Washburne, <i>Asst. in Math.</i>
C. S. Walker, PH. D., <i>Mental and Polit. Science.</i>	H. Babson, B. A., <i>Asst. in English.</i>
W. P. Brooks, B. S., <i>Agr.</i>	F. S. Cooley, B. S., <i>Asst. in Agr.</i>

MICHIGAN.

Michigan Agricultural College, *Agricultural College.*

COURSES OF STUDY.

The courses of study are two, each requiring four years for completion and leading to the degree of B. S.: the agricultural course and the mechanical course. A post-graduate course is also provided.

BOARD OF INSTRUCTION.

L. G. Gorton, <i>Pres.</i>	Philip B. Woodworth, B. S., M. E., (<i>Asst.</i>) <i>Physics.</i>
R. C. Kedzie, M. A., M. D., <i>Chem.</i> ; <i>Curator Chem. Lab.</i>	Alvin B. Noble, PH. B., (<i>Asst.</i>) <i>English Literature and Modern Languages.</i>
W. B. Barrows, B. S., <i>Zoöl. and Ent.</i> ; <i>Curator General Museum.</i>	W. O. Hedrick, B. S., (<i>Asst.</i>) <i>History and Polit. Economy.</i>
William J. Beal, M. S., PH. D., <i>Bot. and Forestry</i> ; <i>Curator Bot. Museum.</i>	F. B. Mumford, B. S., (<i>Asst.</i>) <i>Agr.</i>
E. A. A. Grange, V. S., <i>Vet. Science.</i>	J. N. Hatch, <i>Instr. Math.</i>
I. H. Butterfield, <i>Sec.</i>	Warren Babcock, jr., B. S., (<i>Asst.</i>) <i>Math.</i>
Levi R. Taft, M. S., <i>Hort. and Landscape Gardening</i> ; <i>Supt. Hort. Dept.</i>	P. M. Chamberlain, M. E., (<i>Asst.</i>) <i>Mech. Engin.</i>
Howard Edwards, M. A., LL. D., <i>English Literature and Modern Languages.</i>	D. J. Crosby, B. S., <i>Instr. English.</i>
C. L. Weil, B. S., <i>Mech. Engin.</i> ; <i>Dir. Shops.</i>	A. L. Westcott, B. M. E., <i>Instr. Mech. Engin.</i>
Herman K. Vedder, C. E., <i>Math. and Civil Engin.</i>	G. C. Davis, M. S., <i>Instr. Ent.</i>
C. D. Smith, M. S., <i>Agr.</i> ; <i>Supt. Farm.</i>	C. F. Wheeler, B. S., <i>Instr. Bot.</i>
Edson A. Lewis, 2d Lieut. 18th Infantry, U. S. A., <i>Military Science and Tactics.</i>	R. C. Bradley, <i>Asst. Sec.</i>
Frank S. Kedzie, (<i>Adjunct</i>) <i>Chem.</i>	F. B. Bender, <i>Foreman Wood Shops.</i>
William S. Holdsworth, M. S., (<i>Asst.</i>) <i>Drawing.</i>	E. A. Edgerton, <i>Engin.</i>
	Mrs. Linda E. Landon, <i>Lib.</i>
	Thomas Gunson, <i>Foreman Greenhouses.</i>
	Walter D. Groesbeck, B. S., <i>Foreman Iron Shops.</i>

MINNESOTA.

College of Agriculture of the University of Minnesota. *Minneapolis.*

COURSE OF STUDY.

The course of study requires four years for completion, and leads to the degree of B. Agr.

BOARD OF INSTRUCTION.

Cyrus Northrop, LL. D., <i>Pres.</i>	Harry Snyder, B. S., <i>Agr. Chem.</i>
W. M. Hays, B. S. A., <i>Agr.</i>	M. H. Reynolds, M. D., V. M., <i>Vet. Science.</i>
S. B. Green, B. S., <i>Hort.</i>	Thos. Shaw, <i>Animal Husbandry.</i>
Otto Lugger, Ph. D., <i>Ent. and Bot.</i>	T. L. Haecker, <i>Instr. Dairying.</i>
H. W. Brewster, B. A., (<i>Asst.</i>) <i>Math.</i>	

School of Agriculture of the University of Minnesota, St. Anthony Park.

COURSE OF STUDY.

The course of study requires three years for completion, and leads to a certificate. A short course in dairying is also given.

BOARD OF INSTRUCTION.

H. W. Brewster, B. A., <i>Acting Prin.; Math.</i>	Otto Lugger, Ph. D., <i>Zoöl and Ent.</i>
W. M. Hays, B. S. A., <i>Agr.</i>	M. H. Reynolds, M. D., V. M., <i>Physiol. and Vet. Science.</i>
William Robertson, B. S., <i>Physics and Language.</i>	Thos. Shaw, <i>Animal Husbandry.</i>
C. R. Aldrich, <i>Shopwork and Drawing.</i>	Harry Snyder, B. S., <i>Chem.</i>
T. L. Haecker, <i>Dairy Husbandry.</i>	J. A. Vye, <i>Penmanship and Accounts.</i>
Samuel B. Green, B. S., <i>Hort. and Applied Bot.</i>	Florence A. Brewster, <i>Lib.</i>
	J. M. Drew, <i>Physical Geography and Blacksmithing.</i>

ADDITIONAL INSTRUCTORS IN COURSE IN DAIRYING.

E. J. Graham, <i>Butter-making.</i>	Wm. Boss, <i>Practical Engineering and Steam Fitting.</i>
E. L. Aderhold, <i>Cheese-making, Cheddars, and Flats.</i>	P. M. Paulson, <i>Butter-making.</i>
John Luchsinger, <i>Manufacture Swiss and Brick Cheese.</i>	W. L. Chappell, <i>Cheese-making.</i>
J. H. Haecker, <i>Manufacture Edam and Gouda Cheese.</i>	A. L. Haecker, <i>Milk-testing.</i>

MISSISSIPPI.

Mississippi Agricultural and Mechanical College, Agricultural College.

COURSE OF STUDY.

The course of study requires four years for completion and leads to the degree of B. S. Post-graduate courses and a preparatory course are also provided.

BOARD OF INSTRUCTION.

S. D. Lee, <i>Pres.</i>	W. R. Perkins, B. S., <i>Chem.</i>
W. C. Welborn, B. S., <i>Agr.</i>	J. M. White, M. S., <i>English and History.</i>
A. B. McKay, B. S., <i>Hort.</i>	J. C. Herbert, B. S., <i>Instr. Preparatory Dept.; Instr. Math.</i>
G. C. Creelman, B. S. A., <i>Biol. and Geol.</i>	J. S. Wallace, B. S., <i>Instr. Preparatory Dept.</i>
Tait Butler, V. S., <i>Vet. Science.</i>	A. M. Maxwell, <i>Instr. Writing and Book-keeping.</i>
W. L. Hutchinson, M. S., <i>Chem.</i>	Harry Gwinner, <i>Instr. Drawing; Supt. Mech. Shops.</i>
W. H. Magruder, M. A., <i>Lib.; English.</i>	R. C. King, B. S., <i>Sec. and Purchasing Agent.</i>
B. M. Walker, M. S., <i>Math.</i>	W. H. Barr, M. D., <i>Surgeon.</i>
C. L. Steele, 1st Lieut. 18th Infantry, U. S. A., <i>Military Science and Tactics; (Assoc.) Math.</i>	W. H. Gallaway, <i>Steward and Janitor.</i>
Dabney Lipscomb, M. A., <i>Prin. Preparatory Dept.</i>	J. F. Montgomery, <i>Foreman Farm.</i>
C. T. Ames, B. S., <i>Hort.</i>	
A. M. Herget, B. S., <i>Instr. Drawing and Mech. Shops.</i>	
W. D. Browning, B. M. E., <i>Instr. Drawing and Mech. Shops.</i>	

Alcorn Agricultural and Mechanical College, *Westside*.

COURSES OF STUDY.

The courses of study are three: The academic course of three years; the scientific preparatory course of two years, and the scientific course, requiring four years for completion and leading to the degree of B. S.

BOARD OF INSTRUCTION.

—————, <i>Pres.; Mental and Moral</i>	H. C. Ferguson, <i>Instr. Agr.</i>
<i>Philosophy and Civil Government.</i>	B. F. Ousley, B. D., <i>Instr. Biol.</i>
Joseph Anderson, M. A., <i>Physics, Chem.,</i>	C. A. Snodgrass, B. S., <i>Instr. English</i>
<i>and History.</i>	<i>Branches.</i>
A. J. Howard, M. A., <i>Math.</i>	G. J. Williams, B. S., <i>Instr. English</i>
H. A. Clark, <i>Polit. Economy, Bookkeeping</i>	<i>Branches.</i>
<i>and Rhetoric.</i>	R. B. Swayzee, <i>Instr. English Branches.</i>
H. L. Stiles, B. S., <i>Instr. English Branches.</i>	J. B. Bemiss, <i>Instr. Carpentering.</i>
	W. Logan, <i>Instr. Blacksmithing.</i>

MISSOURI.

College of Agriculture and Mechanic Arts of the University of Missouri, *Columbia.*

COURSE OF STUDY.

The course of study requires four years for completion and leads to the degree of B. Agr. There are also two short courses, a farmers' lecture course of three months, and a two years' elementary course. The college also offers a post graduate course, which requires two years for completion, and leads to the degree of M. Agr.

BOARD OF INSTRUCTION.

R. H. Jesse, LL. D., <i>Pres.</i>	Alexander Martin, M. A., LL. D., <i>Lec-</i>
E. D. Porter, M. A., PH. D., <i>Dean.</i>	<i>turer on Agricultural Law.</i>
W. J. Quick, B. S., <i>Agr.</i>	C. W. Marks, B. E., <i>Supt. School Mech.</i>
P. Schweitzer, PH. D., <i>Chem.</i>	<i>Arts.</i>
E. A. Allen, L. D., <i>English.</i>	C. B. Rearick, <i>Drawing.</i>
L. M. DeFoe, PH. D., <i>Math.</i>	H. Van Blarcom, <i>Asst. in Mech. Arts.</i>
G. D. Purinton, M. A., PH. D., M. D., <i>Biol.</i>	M. S. King, <i>Instr. Commercial School.</i>
M. L. Lipscomb, M. A., <i>Physics.</i>	J. W. Connaway, M. D., D. V. S., <i>Vet.</i>
S. A. Smoke, Lieut., U. S. A., <i>Military</i>	<i>Science.</i>
<i>Science.</i>	C. A. Keffer, M. H., <i>Hort.</i>
G. C. Broadhead, M. S., <i>Geol. and Min.</i>	F. C. Hicks, PH. D., <i>History and Polit.</i>
	<i>Science.</i>

Lincoln Institute, *Jefferson City.*

COURSE OF STUDY.

No course of study in agriculture has been arranged owing to the small amount of money appropriated for that purpose.

BOARD OF INSTRUCTION.

Inman E. Page, M. A., <i>Pres.; Metaphysics</i>	A. P. Hollis, <i>Language and History.</i>
<i>and School Economy.</i>	J. M. Rutledge, <i>Asst. in Math.</i>
J. L. Love, B. A., <i>Math.</i>	Luellen Williams, <i>Asst. in Language.</i>
R. L. Harris, <i>Natural Science.</i>	G. B. Johnson, <i>Asst. in Industrial Dept.</i>
W. A. Magee, <i>Supt. Industrial Dept.</i>	Rebecca Massey, <i>Instr. Music.</i>
	L. C. Anthony, <i>Matron.</i>

MONTANA.

The Montana College of Agriculture and Mechanic Arts, Bozeman.

COURSES OF STUDY.

There are courses of study in agriculture, domestic economy, applied science, and business. The first three require four years each for completion and lead to degrees; the business courses require one and two years and lead to no degree. Preparatory work is also provided.

BOARD OF INSTRUCTION.

A. M. Ryon, M. E., *Pres.; Engin.*

S. M. Emery, *Hort.*

Luther Foster, M. S. A., *Agr. and Bot.*

F. W. Traphagen, PH. D., F. C. S., *Chem. and Natural Sciences.*

R. E. Chandler, M. E., *Math. and Mech. Engin.*

W. L. Williams, V. S., *Vet. Science.*

B. F. Maiden, B. A., *English; Prin. Preparatory Dept.*

H. G. Phelps, *Prin. Business Dept.*

NEBRASKA.

Industrial College of the University of Nebraska, Lincoln.

COURSES OF STUDY.

The courses of study are as follows, each requiring four years for completion and leading to the degree of B. S.: General scientific course, electrical and steam engineering course, agricultural course, and civil engineering course. One and two years' courses in elementary agriculture are also provided.

BOARD OF INSTRUCTION.

James H. Canfield, M. A., *Chancellor.*

C. L. Ingersoll, M. S., *Dean; Agr.*

H. H. Nicholson, M. A., *Chem.*

H. E. Hitchcock, PH. D., *Math.*

L. A. Sherman, PH. D., *English Literature.*

C. E. Bessey, PH. D., *Bot.*

Rachel Lloyd, PH. D., *Anal. Chem.*

DeW. B. Brace, PH. D., *Physics.*

E. W. Davis, PH. D., *Math.*

J. J. Pershing, 2d Lieut. 6th Cavalry, U. S. A., *Military Science and Tactics.*

F. W. Adams, B. L., *English.*

H. K. Wolfe, B. A., PH. D., *Philosophy.*

H. W. Caldwell, PH. B., *American History and Civics.*

A. H. Edgren, PH. D., *Romance Languages.*

Laurence Fossler, M. A., (*Assoc.*) *Germanic Languages.*

E. H. Barbour, PH. D., (*Assoc.*) *Geol.*

H. B. Ward, PH. D., (*Assoc.*) *Zoöl.*

F. M. Fling, PH. D., (*Assoc.*) *European History.*

W. G. Taylor, PH. D., *Polit. and Economic Science.*

F. W. Card, M. S., (*Assoc.*) *Hort.*

R. B. Owens, E. E., (*Assoc.*) *Elect. Engin.*

H. N. Allen, PH. D., (*Adjunct*) *Physics.*

T. M. Hodgman, B. A., (*Adjunct*) *Math.*

R. W. Furnas, *Lecturer on Forestry.*

O. V. P. Stout, B. C. E., (*Adjunct*) *Civil Engin.*

Lawrence Bruner, *Instr. Ent.*

G. B. Hussey, PH. D., *Asst. Prin. Preparatory Dept.*

Mary A. Tremain, *Instr. History.*

Herbert Bates, B. A., *Instr. English.*

C. R. Richards, M. E., *Manual Training.*

Wilbur P. Bowen, *Instr. Physical Training.*

Kate Wilder, *Instr. Physiol. and Hygiene.*

A. M. Wilson, PH. D., *Instr. Latin.*

H. M. Belden, *Instr. English.*

J. C. White, B. Sc., *Instr. Agr. Chem.*

J. Tremaine, *Instr. Latin.*

Cora Parker, *Instr. Clay Modeling and Wood Carving.*

Clara Conklin, B. A., *Instr. German.*

P. B. Burnett, M. A., *Instr. German.*

A. L. Candy, M. A., *Instr. Math.*

W. B. Hampsen, M. E., *Instr. Drawing.*

Emil Salich, C. E., *Lecturer in Sugar School.*

NEVADA.

School of Agriculture of the Nevada State University, Reno.

COURSE OF STUDY.

The regular course requires four years for completion and leads to the degree of B. S. A short course in agriculture is also provided, requiring five months of each year for four years and leading to no degree.

BOARD OF INSTRUCTION.

S. A. Jones, M. A., PH. D., <i>Pres.</i>	J. M. Neall, 1st Lieut. 4th Cavalry, U. S. A., <i>Military Science and Tactics, Math. and Modern Languages.</i>
Hannah K. Clapp, M. A., <i>Preceptress and Lib.</i>	R. H. McDowell, B. S., <i>Agr. and Hort.</i>
W. McN. Miller, B. S., <i>Anatomy, Physics and Geol.</i>	T. W. Cowgill, M. A., <i>English.</i>
R. D. Jackson, PH. B., <i>Mining, Metallurgy and Assaying.</i>	Richard Brown, <i>Supt. Mech. Dept.</i>
J. Warne Phillips, D. S., <i>Chem. and Physics.</i>	Henry Thurtell, B. S., <i>Mech. and Mech. Drawing.</i>
F. H. Hillman, M. S., <i>Ent. and Bot.</i>	James E. Church, jr., B. A., <i>Instr. Latin.</i>
Mrs. Mary W. Emery, <i>Pedagogy; Prin. Normal School.</i>	Frederick Stadtmüller, B. S., <i>Chem. and Physics.</i>
Robert Lewers, <i>Polit. Economy and Commercial Law.</i>	

NEW HAMPSHIRE.

New Hampshire College of Agriculture and the Mechanic Arts, Hanover.

COURSES OF STUDY.

There are five courses of study, each requiring four years for completion and leading to the degree of B. S.: Course in agriculture, course in chemistry, course in mechanical engineering, course in electrical engineering, and general course open to women.

BOARD OF INSTRUCTION.

C. S. Murkland, M. A., PH. D., <i>Pres.</i>	Chas. L. Parsons, B. S., <i>General and Anal. Chem.</i>
Chas. H. Pettee, M. A., C. E., <i>Dean; Math. and Civil Engin.</i>	Albert Kingsbury, M. E., <i>Mech. Engin.</i>
Henry G. Jesup, M. A., <i>Natural History.</i>	H. H. Lamson, M. D., <i>Biol. and Bact.</i>
Clarence W. Scott, M. A., <i>English Language and Literature.</i>	Geo. L. Teeple, M. E., <i>Instr. Elect. Engin. and Physics.</i>
Geo. H. Whitcher, B. S., <i>Agr.</i>	Edwin B. Davis, B. L., <i>Instr. Modern Languages.</i>
Clarence M. Weed, D. S., <i>Zoöl. and Ent.</i>	John N. Brown, <i>Foreman Machine Work.</i>
Albert H. Wood, B. S., (<i>Assoc.</i>) <i>Agr.</i>	Allen G. Lowell, <i>Foreman Woodwork.</i>
Fred. W. Morse, B. S., <i>Organic Chemistry.</i>	

NEW JERSEY.

Rutgers Scientific School, New Brunswick.

COURSES OF STUDY.

There are five distinct courses of study: A course in agriculture, a course in civil engineering and mechanics, a course in chemistry, a course in electricity, and a course in biology. Each course requires four years for completion and leads to the degree of B. S.

BOARD OF INSTRUCTION.

- Austin Scott, PH. D., LL. D., *Pres.; History and Polit. Science.*
 Jacob Cooper, D. D., D. C. L., *Logic and Mental Philosophy.*
 Carl Meyer, D. D., *Modern Languages and Literature.*
 F. C. Van Dyck, PH. D., *Physics and Experimental Mech.*
 E. A. Bowser, C. E., LL. D., *Math. and Engin.*
 C. E. Hart, D. D., *English and Literature.*
 Louis Bevier, jr., PH. D., *Greek; Sec. Extension Dept.*
 E. S. Shumway, PH. D., *Latin.*
 A. A. Titsworth, M. S., C. E., *Graphics and Math.*
 Julius Nelson, PH. D., *Biol.*
 B. D. Halsted, D. SC., *Bot. and Hort.*
 J. B. Smith, D. SC., *Ent.*
 E. B. Voorhees, M. A., *Agr.*
 W. R. Duryee, D. D., *Ethics, Evidences of Christianity, and English Bible.*
 A. H. Chester, M. E., PH. D., D. SC., *Chem.*
 J. J. Brereton, 1st Lieut. 24th Infantry, U. S. A., *Military Science and Tactics.*
 J. C. Van Dyke, L. H. D., *History of Art.*
 R. W. Prentiss, *Math. and Astronomy.*
 E. R. Payson, PH. D., *History and Art of Teaching.*
 E. L. Stephenson, PH. D., *History.*
 I. S. Upson, M. A., *Lib. and Registrar.*
 C. L. Speyers, PH. B., (*Assoc.*) *Chem.*
 Thomas Logie, PH. D., *Romance Languages.*
 E. L. Barbour, *Instr. Elocution.*
 G. A. Mitchell, B. S., *Asst. in Chem.*
 W. E. Breazeale, M. PH., *Instr. Math.*
 Eugene Betts, B. S., *Instr. Elec. and Physics.*
 L. R. Gibbs, M. A., *Instr. and Extension Lecturer in English.*
 Woldemar Loehner, *Instr. Modern Languages.*
 W. S. Myers, B. S., F. C. S., *Asst. in Chem.*

NEW MEXICO.

New Mexico College of Agriculture and Mechanic Arts, Las Cruces.

COURSES OF STUDY.

The courses of study are four: A course in science and agriculture, a course in mechanical engineering, a course in civil engineering, and a classical and scientific course.

BOARD OF INSTRUCTION.

- H. Hadley, M. A., *Pres.*
 A. E. Blount, M. A., *Hort. and Agr.*
 E. O. Wooton, B. S., *Bot.*
 Arthur Goss, B. S., A. C., *Chem.*
 J. P. Owen, *History and Polit. Science.*
 T. D. A. Cockerell, *Biol.*
 C. T. Hagerty, B. S., *Math.*
 A. J. Wiechardt, M. M. E., *Mech. Engin.*
 R. F. Hare, M. S., *Asst. in Chem.*
 F. F. Barker, LL. B., *Instr. Languages.*
 A. E. Davisson, *Prin. Preparatory School.*

NEW YORK.

College of Agriculture of Cornell University, Ithaca.

COURSES OF STUDY.

The regular course of study requires four years for completion and leads to the degree of B. S. A post-graduate course, leading to the degree of M. S., is provided and special courses are also arranged.

BOARD OF INSTRUCTION.

Jacob G. Schurman, B. A., D. Sc., LL. D., <i>Pres.</i>	L. H. Bailey, M. S., <i>General and Experimental Hort.</i>
Geo. C. Caldwell, B. S., Ph. D., <i>Agr. and Anal. Chem.</i>	Henry H. Wing, M. S., (<i>Asst.</i>) <i>Animal Industry and Dairy Husbandry.</i>
James Law, F. R. C. V. S., <i>Vet. Medicine and Surgery.</i>	Louis M. Dennis, Ph. B., B. S., (<i>Asst.</i>) <i>Anal. Chem.</i>
Albert N. Prentiss, M. S., <i>Bot., Hort. and Arbor.</i>	Geo. F. Atkinson, Ph. B., (<i>Asst.</i>) <i>Cryptogamic Bot.</i>
Isaac P. Roberts, M. Agr., <i>Agr.</i>	Willard W. Rowlee, D. Sc., (<i>Asst.</i>) <i>Bot.</i>
John H. Comstock, B. S., <i>Ent. and General Invertebrate Zoöl.</i>	E. G. Lodeman, B. S., <i>Instr. Hort.</i>
	A. D. MacGillivray, <i>Asst. in Ent.</i>
	G. C. Watson, M. S., <i>Asst. in Agr.</i>

NORTH CAROLINA.

The North Carolina College of Agriculture and Mechanic Arts, *Raleigh.*

COURSES OF STUDY.

The general courses of study are two, each requiring four years for completion: Agricultural course, leading to the degree of B. S. A., and mechanical course, leading to the degree of B. E.

BOARD OF INSTRUCTION.

Alexander Q. Holladay, <i>Pres.; History.</i>	C. B. Park, <i>Supt. Shops.</i>
B. Irby, M. S., <i>Agr.</i>	R. E. L. Yates, M. A., (<i>Adjunct</i>) <i>Math.</i>
W. F. Massey, C. E., <i>Hort., Arbor. and Bot.</i>	B. S. Skinner, <i>Asst. in Agr. and Hort. Practice.</i>
W. A. Withers, M. A., <i>Chem.; Sec.</i>	L. T. Yarborough, B. E., <i>Instr. Mech.</i>
D. H. Hill, jr., M. A., <i>English.</i>	S. E. Asbury, B. S., <i>Instr. Chem.</i>
Richard Henderson, Lieut., U. S. N., <i>Military Tactics.</i>	C. B. Williams, B. S., <i>Instr. Chem.</i>
W. C. Reddick, B. A., C. E., <i>Mech. and Applied Math.</i>	J. T. Meacham, B. S., <i>Instr. Dairying.</i>
F. E. Emery, B. S., (<i>Asst.</i>) <i>Agr.</i>	J. P. Williamson, M. D., <i>Lecturer on Vet. Science.</i>
C. M. Pritchett, <i>Instr. Mech.</i>	Mrs. Sue C. Carroll, <i>Matron.</i>
	J. B. Dunn, M. D., <i>Physician.</i>

NORTH DAKOTA.

North Dakota Agricultural College, *Fargo.*

COURSES OF STUDY.

The course in agriculture requires four years for completion and leads to the degree of B. S. In addition to the regular course there is a short course in agriculture and domestic economy, which requires three months in each of two consecutive winters for completion.

BOARD OF INSTRUCTION.

J. B. Power, <i>Pres.</i>	L. S. Bottenfield, M. A., <i>Modern Languages.</i>
E. F. Ladd, B. S., <i>Chem.</i>	H. W. McArdle, B. S., <i>Instr. Math.</i>
T. D. Hinebauch, M. S., V. S., <i>Vet. Science.</i>	W. H. Whalen, Ph. B., <i>Instr. English.</i>
C. B. Waldron, B. S., <i>Hort. and Forestry.</i>	W. G. Hayden, <i>Accountant and Bursar.</i>
H. L. Bolley, M. S., <i>Bot. and Zoöl.</i>	E. E. Kaufman, B. S. A., <i>Asst. in Agr.</i>
E. S. Keene, B. S., <i>Mech.</i>	Mrs. P. A. Evans, <i>Lib.</i>
J. H. Shepperd, M. S. A., <i>Agr.</i>	W. G. Hiatte, <i>Supt. Farm.</i>

OHIO.

Ohio State University, Columbus.

COURSES OF STUDY.

The general courses of study are five, requiring four years each for completion and leading, respectively, to the degrees of B. A., PH. B., and B. S. There are now three courses leading to the degree of PH. B.; in one the languages are Latin and French, in another German and French, while in the third English studies predominate. The following technical courses are provided: A course for the degree of B. S. A., requiring four years; a course for the degree of B. S. H., requiring four years; a course for the degree of D. V. M., requiring three years; a course for the degree of C. E., requiring four years; two courses for the degree of M. E., each requiring four years, one in mechanical engineering, and one in electrical engineering; a course for the degree of engineer of mines, requiring four years; a course for the degree of graduate in pharmacy, requiring three years; a short course in agriculture, requiring two years; and a short course in mining, requiring two years. Provision is also made for post-graduate study leading to degrees, and for one year of preparatory work.

BOARD OF INSTRUCTION.

- | | |
|--|---|
| W. H. Scott, M. A., LL. D., <i>Pres.; Philos-</i>
<i>ophy.</i> | J. V. Denny, B. A., (<i>Assoc.</i>) <i>Rhetoric.</i> |
| Edward Orton, PH. D., LL. D., <i>Geol.</i> | G. W. McCoard, M. A., <i>Math.</i> |
| S. A. Norton, PH. D., LL. D., <i>Chem.</i> | F. W. Sperr, M. E., <i>Mining Engin.</i> |
| N. S. Townshend, M. D. (<i>Emeritus</i>), <i>Agr.</i> | J. N. Bradford, M. E., <i>Drawing.</i> |
| S. W. Robinson, C. E., <i>Mech. Engin.</i> | G. P. Coler, B. A., <i>Philosophy.</i> |
| N. W. Lord, M. E., <i>Min. and Metallurgy.</i> | F. C. Caldwell, B. A., (<i>Asst.</i>) <i>Elect. Engin.</i> |
| S. C. Derby, M. A., <i>Latin.</i> | W. H. Siebert, M. A., (<i>Asst.</i>) <i>History and</i>
<i>Polit. Science.</i> |
| W. R. Lazenby, M. AGR., <i>Hort.</i> | Wm. McPherson, jr., M. SC., (<i>Asst.</i>)
<i>Chem.</i> |
| J. R. Smith, M. A., <i>Lib.; Greek.</i> | O. B. Jones, <i>Lib.</i> |
| H. A. Weber, PH. D., <i>Agr. Chem.</i> | C. W. Mesloh, B. A., <i>Asst. in German.</i> |
| B. F. Thomas, PH. D., <i>Physics.</i> | J. R. Taylor, B. A., <i>Asst. in Drawing.</i> |
| G. W. Knight, PH. D., <i>Sec. Faculty; His-</i>
<i>tory and Polit. Science.</i> | C. L. Arnold, B. S., <i>Asst. in Math.</i> |
| H. J. Detmers, D. V. M., <i>Vet. Surgery.</i> | C. B. Morrey, B. A., <i>Asst. in Physiol.</i> |
| R. D. Bohannon, B. S., C. E., M. E., <i>Math.</i>
<i>and Astronomy.</i> | C. A. Dye, PH. G., <i>Asst. in Pharmacy.</i> |
| D. S. Kellicott, PH. D., <i>Zoöl. and Ent.</i> | L. M. Bloomfield, B. AGR., <i>Asst. in Agr.</i>
<i>Chem.</i> |
| C. N. Brown, C. E., <i>Civil Engin.</i> | W. C. Werner, <i>Asst. in Bot.</i> |
| E. A. Eggers, <i>German.</i> | F. J. Combs, <i>Foreman Forge Rooms.</i> |
| Albert M. Bleile, M. D., <i>Anatomy and</i>
<i>Physiol.</i> | E. A. Kemmler, C. E., <i>Asst. in Civil Engin.</i> |
| Eugene T. Wilson, 2d Lieut. 1st Artillery,
U. S. A., <i>Military Science and Tactics.</i> | J. E. Boyd, B. S., <i>Asst. in Physics.</i> |
| W. A. Kellerman, PH. D., <i>Bot. and For-</i>
<i>estry.</i> | H. C. Lord, B. S., <i>Asst. in Math. and As-</i>
<i>tronomy.</i> |
| Thos. F. Hunt, B. S., <i>Agr.</i> | Florence Bascomb, PH. D., <i>Asst. in Geol.</i> |
| G. B. Kauffman, B. S., (<i>Assoc.</i>) <i>Pharmacy.</i> | Wallace S. Eldon, M. A., <i>Asst. in Latin</i>
<i>and French.</i> |
| Jas. Chalmers, PH. D., (<i>Assoc.</i>) <i>English</i>
<i>Literature.</i> | D. S. White, D. V. M., <i>Asst. in Vet. Medi-</i>
<i>cine.</i> |
| B. L. Bowen, PH. D., (<i>Assoc.</i>) <i>Romance</i>
<i>Languages and Literature.</i> | E. A. Hitchcock, <i>Asst. in Mech. Engin.</i> |
| | C. W. Weick, <i>Foreman Pattern Room.</i> |
| | W. A. Knight, <i>Foreman Machine Room,</i> |

OKLAHOMA.

Agricultural and Mechanical College of Oklahoma, Stillwater.

COURSE OF STUDY.

The course of study requires four years for completion, and leads to the degree of B. Sc.

BOARD OF INSTRUCTION.

R. J. Barker, C. E., <i>Pres.; Moral, Mental and Economic Science.</i>	A. C. Magruder, B. Sc., <i>Agr.</i>
J. C. Neal, Ph. C., M. D., <i>Natural Science.</i>	G. L. Holter, B. Sc., <i>Chem. and Physics.</i>
E. F. Clark, <i>Math.</i>	F. A. Waugh, B. Sc., <i>Hort.</i>
W. W. Hutto, B. Sc., <i>English Literature; Tactician and Commandant.</i>	H. E. Thompson, B. Sc., <i>Prin. Preparatory Dept.</i>
	J. M. Halbbrook, <i>Asst. in Preparatory Dept.</i>

OREGON.

Oregon State Agricultural College, Corvallis.

COURSES OF STUDY.

The courses of study are three: A course in agriculture, requiring three years for completion and leading to the degree of B. S. A.; a course in mechanical engineering, requiring four years for completion and leading to the degree of B. M. E.; and a course in household economy (for girls) leading to the degree of B. H. E.

BOARD OF INSTRUCTION.

J. M. Bloss, M. A., <i>Pres.; Mental and Moral Science.</i>	George Coote, <i>Instr. Hort.</i>
J. D. Letcher, C. E., <i>Math. and Engin.</i>	W. W. Bristow, B. A., <i>Prin. Preparatory Dept.; Bookkeeping.</i>
F. Berchtold, M. A., <i>Modern Languages, History, Drawing and Music.</i>	J. F. Fulton, B. S., A. C., <i>Chem.</i>
Margaret C. Snell, M. D., <i>Household Economy and Hygiene.</i>	C. D. Thompson, B. A., <i>Foreman Agr. Dept.</i>
G. A. Covell, M. S., <i>Mech. and Mech. Engin.</i>	E. M. Belknap, <i>Engin.; Instr. Wood and Metal Work.</i>
F. L. Washburn, B. A., <i>Zoöl. and Ent.</i>	H. R. Clark, <i>Instr. Printing.</i>
H. T. French, M. S., <i>Agr.</i>	Emile Pernot, <i>Instr. Photography and Photo-gravure.</i>
M. Craig, M. S., <i>Bot.</i>	Mrs. Ida Callahan, B. S., <i>Asst. in Preparatory Dept.</i>
G. W. Shaw, M. A., <i>Chem. and Physics.</i>	
J. B. Horner, M. A., <i>English.</i>	

PENNSYLVANIA.

Pennsylvania State College, State College.

COURSES OF STUDY.

The courses of study are as follows, each requiring four years for completion unless otherwise specified: General science course; Latin scientific course; course in agriculture; course in chemistry; course in physics and electrotechnics; course in civil engineering; course in mechanical engineering; course in mining engineering; course in natural history; course in mechanic arts, requiring three years; ladies' course in literature and science, requiring two years; a special course in chemistry and a special course in mining engineering, each requiring two years for completion. The four years' courses lead to the degree of B. S., the diploma containing mention of line of work pursued. Provision is also made for post-graduate study, leading to advanced degrees, and for preparatory work.

BOARD OF INSTRUCTION.

- Geo. W. Atherton, LL. D., *Pres.; Polit. and Social Science.*
 William A. Buckhout, M. S., *Bot. and Hort.*
 I. Thornton Osmond, M. S., M. A., *Physics.*
 Harriet A. McElwain, M. A., *Lady Prin.; History.*
 Louis E. Reber, B. S., M. A., *Mech. and Mech. Engin.*
 William Frear, PH. D., *Sec. Faculty; Agr. Chem.*
 Geo. G. Pond, M. A., PH. D., *Chem.*
 Henry P. Armsby, PH. D., *Lecturer on Animal Chem. and Cattle Feeding.*
 Edwin E. Sparks, M. A., *Prin. Preparatory Dept.*
 Henry J. Waters, B. AGR., *Agr.*
 Henry T. Fernald, PH. D., *Zoöl.*
 Benjamin Gill, M. A., *Latin.*
 William C. Thayer, M. A., *Modern Languages.*
 E. W. McCaskey, 1st Lieut. 21st Infantry, U. S. A., *Military Science and Tactics.*
 John Pemberton, C. E., U. S. N., (*Assoc.*) *Mech. Engin.*
 M. C. Ihlseng, M. E., C. E., PH. D., *Mining Engin. and Geol.*
 J. P. Jackson, B. S., M. E., (*Asst.*) *Elect. Engin.*
 G. C. Butz, M. S., (*Asst.*) *Hort.*
 T. W. Kinkaid, U. S. N., (*Asst.*) *Mech. Engin.*
 Fred E. Foss, B. S., M. A., (*Asst.*) *Civil Engin.*
 F. P. Emery, M. A., (*Asst.*) *English and Rhetoric.*
 W. H. Caldwell, B. S., (*Asst.*) *Agr.*
 H. H. Stoek, B. S., M. E., (*Asst.*) *Mining Engin. and Metallurgy.*
 M. M. Garver, B. S., (*Asst.*) *Physics.*
 F. E. Tuttle, B. A., PH. D., *Instr. Chem. and Min.*
 Jennie J. Willard, *Instr. Music.*
 T. R. Beyer, B. S., C. E., *Instr. Civil Engin.*
 Anna E. Redifer, *Instr. Industrial Art and Design.*
 W. S. Walker, B. S., PH. D., *Instr. Chem.*
 M. J. Thompson, B. A., *Instr. Math.*
 W. M. Towle, B. S., *Instr. Mech. Engin. and Foreman Shops.*
 J. M. Willard, B. A., *Instr. Math.*
 T. C. Hopkins, M. S., M. A., *Instr. Geol.*
 E. W. Runkle, M. A., PH. D., *Instr. Psychology and Ethics.*
 F. J. Pond, B. S., *Asst. in Chem.*
 E. P. Butts, B. S., *Asst. in Civil Engin.*
 Hervey E. Dunkle, B. S., *Asst. in Mech. Drawing.*
 J. M. Wolfe, M. A., *Instr. Math. in Preparatory Dept.*
 W. M. Taggart, *Instr. English and Latin in Preparatory Dept.*
 G. W. Hoskins, *Instr. Physical Training.*

RHODE ISLAND.

Department of Agriculture and Mechanic Arts of Brown University, Providence.

COURSES OF STUDY.

The courses of study are five, each requiring four years for completion: The course for the degree of B. A., the course for the degree of Ph. B., the course for the degree of B. S., the course for the degree of C. E., and the course for the degree of M. E. Studies in agriculture and ancillary sciences forming a portion of the work of the fourth year are required of all students appointed to the scholarships afforded by the income of the national grant. A continually widening range of studies in the branches relating to agriculture, and in the various mathematical and mechanical arts, is offered to all the students in the university.

BOARD OF INSTRUCTION.

- E. B. Andrews, D. D., LL. D., *Pres.*; *Moral and Intellectual Philosophy.*
 Albert Harkness, PH. D. (*Emeritus*) *Greek.*
 B. F. Clark, M. A., *Math. and Engin.*
 J. H. Appleton, M. A., *Chem.*
 E. W. Blake, M. A., *Physics.*
 J. W. P. Jenks, M. A., *Agr. Zoöl.*
 W. C. Poland, M. A., *Fine Arts.*
 Alonzo Williams, M. A., *German.*
 A. S. Packard, PH. D., *Zoöl. and Geol.*
 N. F. Davis, M. A., *Pure Math.*
 W. W. Bailey, B. P., *Bot.*
 Winslow Upton, M. A., *Astronomy.*
 C. V. Chapin, M. D., *Physiol.*; *Dir. Physical Culture.*
 J. I. Manatt, LL. D., *Greek.*
 J. F. Jameson, PH. D., *History.*
 W. C. Bronson, M. A., (*Assoc.*) *English Literature.*
 A. G. Harkness, M. A., (*Assoc.*) *Latin.*
 H. B. Gardner, PH. D., *Polit. Economy.*
 J. M. Manly, PH. D., *English Language.*
 G. G. Wilson, PH. D., (*Assoc.*) *Polit. and Social Science.*
 W. G. Everett, M. A., *Instr. Latin and Greek.*
 H. P. Manning, PH. D., *Instr. Math.*
 F. T. Guild, M. A., *Sec. Faculty.*
 E. H. Brownell, *Instr. Civil Engin.*
 H. C. Bumpus, PH. D., *Comparative Anatomy.*
 Courtney Langdon, B. A., (*Assoc.*) *Romance Languages.*
 L. Sears, L. H. D., *Rhetoric.*
 W. H. Munro, M. A., (*Assoc.*) *History*; *Dir. Univ. Extension.*
 O. E. Randall, M. A., (*Assoc.*) *Mech. Drawing.*
 J. R. Jewett, PH. D., (*Assoc.*) *Semitic Languages.*
 E. B. Delabarre, *Psychology.*
 E. E. Calder, *Instr. Chem.*
 L. F. Snow, M. A., *Dean of Women's College.*
 W. D. Mount, M. E., *Instr. Practical Physics.*
 A. C. Crowell, M. A., *Instr. French and German.*
 A. Scott, M. A., *Instr. German.*
 W. M. Saunders, *Instr. Chem.*
 J. F. Greene, B. A., *Instr. Greek and Latin.*
 F. E. Parker, B. A., *Instr. Physical Culture.*
 Wm. J. Pardee, 1st Lieut. 25th Infantry, U. S. A., *Military Tactics.*
 J. L. Alger, B. A., *Instr. Pure Math.*
 C. M. Brink, B. A., *Instr. Rhetoric.*
 E. C. Burnham, B. S., *Instr. Mech. Drawing and Mech. Engin.*
 B. Newhall, PH. D., *Instr. Greek.*
 A. B. Johnson, M. A., *Instr. Romance Languages.*
 James Seth, M. A., (*Assoc.*) *Natural Theology.*
 G. W. Field, PH. D., (*Assoc.*) *Cellular Biol.*
 S. S. Colvin, B. P., *Instr. English.*
 J. Q. Dealey, M. A., *Instr. English.*
 A. D. Palmer, jr., B. P., *Instr. Physics.*
 F. P. Gorham, B. A., *Instr. Biol.*
 I. L. Foster, B. A., *Instr. French.*
 A. R. Wightman, B. A., *Instr. English.*
 O. P. Durkee, B. P., *Instr. English.*
 G. P. Merrill, B. A., *Instr. English.*

Rhode Island College of Agriculture and Mechanic Arts, Kingston.

COURSES OF STUDY.

The course of study in agriculture requires four years for completion and leads to the degree of B. Agr. Partial courses and a winter course are also provided.

BOARD OF INSTRUCTION.

- J. H. Washburn, PH. D., *Pres.*; *Chem.*
 C. O. Flagg, B. S., *Agr.*
 L. F. Kinney, B. S., *Hort. and Bot.*
 H. J. Wheeler, PH. D., *Geol.*
 A. Bosworth, M. A., *Math.*
 O. C. Wiggin, M. D., *Vet. Science.*
 W. E. Drake, B. S., *Mech. Engin.*
 B. B. Howard, LL. B., *Lecturer on Business and Rural Law*; *Instr. Bookkeeping,*
 Samuel Cushman, *Lecturer on Bee Keeping.*
 E. J. Watson, M. A., *Instr. English, French, and German.*
 T. C. Rodman, *Instr. Wood and Iron Work.*
 F. A. Lane, *Instr. Mech. Drawing*; *Asst. Instr. Woodwork.*
 M. P. Helme, *Instr. Drawing.*
 B. L. Hartwell, B. S., *Instr. Music,*

SOUTH CAROLINA.

Clemson Agricultural College, *Clemson College*.

COURSES OF STUDY.

There are two courses of study offered in the freshman and sophomore years, one in chemistry and agriculture and the other in mechanics and engineering.

BOARD OF INSTRUCTION.

E. B. Craighead, *Pres.*

H. A. Strode, *Math.*

M. B. Hardin, *Chem.*

W. S. McGee, M. S., *Agr.*

C. M. Furman, *English.*

C. W. Welch, *Physics.*

W. S. Morrison, *History.*

T. Q. Donaldson, jr., Lieut., U. S. A., *Military Science.*

S. Tompkins, (*Assoc.*) *Civil and Mech. Engin.*

J. G. Clinkscales, (*Assoc.*) *Math.*

T. P. Harrison, (*Assoc.*) *English.*

R. N. Brackett, (*Assoc.*) *Chem.*

J. W. Hart, (*Adjunct*) *Agr.*

L. A. Clinton, (*Asst.*) *Agr.*

Williams Welch, *Instr. Drawing.*

W. F. Moncreiff, *Tutor English.*

College of Agriculture and Mechanics' Institute, of Claflin University, *Orangeburg.*

COURSES OF STUDY.

The regular courses of study are ten: The college classical course, requiring four years for completion and leading to the degree of B. A.; the college scientific course, requiring four years and leading to the degree of B. S.; the college philosophical course, requiring four years and leading to the degree of Ph. B.; the college preparatory course and the normal course, each requiring three years and leading to a diploma; the English course, requiring seven years and leading to a certificate; the kindergarten course, requiring one year and leading to a certificate; the English Bible course, requiring four years and leading to a certificate; the music course, requiring four years and leading to a certificate; and the art course, requiring three years and leading to a certificate. Twenty industrial courses are also provided to be pursued in connection with the courses above.

BOARD OF INSTRUCTION.

L. M. Dunton, M. A., D. D., *Pres.; Agr.*

J. S. Heyward, M. A., *Physical Science.*

Mrs. L. M. Dunton, M. A., *Preceptress; Rhetoric and Literature.*

W. L. Bulkley, M. A., *Greek, Latin, German and Literature.*

Mortimer Glover, B. A., *History and Polit. Science.*

P. F. Stevens, D. D., *Math.; Instr. English Bible.*

Mrs. C. D. Mead, *Lib.; Literature.*

Thos. J. Penfield, B. A., *Greek and Literature.*

Chas. H. Sears, *Pedagogics.*

Jos. C. Hartzell, jr., *Biol. and Min.*

C. D. Mead, M. A., *Prin. English Schools.*

R. C. Bates, *Drawing.*

Helen H. Thresher, *Music.*

SOUTH DAKOTA.

South Dakota Agricultural College, *Brookings.*

COURSES OF STUDY.

The courses of study are four: A course in agriculture; a course in domestic economy; a course in mechanic arts, and a course in pharmacy. The first three require four years for completion and lead to the degree of B. S.; the last requires two years and leads to no degree. There is also a short course in steam engineering.

BOARD OF INSTRUCTION.

- Lewis McLouth, M. A., PH. D., *Pres.*; *Astronomy and Physics.*
 E. C. Chilcott, *Agr.*
 Jno. M. Parkinson, M. A.; LL. B., *History and Polit. Economy.*
 Nellie E. Folsom, B. S., *Preceptress; Instr. Languages.*
 J. H. Shepard, D. S., *Chem.*
 L. C. Corbett, *Hort. and Forestry.*
 A. S. Frost, 1st Lieut. 25th Infantry, U. S. A., *Military Science and Tactics.*
 W. H. H. Phillips, M. A., PH. D., *Math.*
 H. H. Wheaton, *Dairy Science.*
 D. A. Cormack, D. V. S., *Vet. Science.*
 H. N. Ott, PH. M., *Zoöl. and Animal Pathology.*
 C. G. Hopkins, B. S., *Asst. in Chem.*
 T. A. Williams, M. S., (*Acting*) *Bot. and Ent.*
 C. R. Waters, M. A., *English.*
 Austin B. Crane, B. S., *Asst. in Math.*
 Hubert B. Bathews, B. S., *Asst. in Physics and Meteorology.*
 Loren E. Winslow, *Instr. Sten. and Typewriting.*
 Ed. F. Hewit, *Sec. and Steward.*
 Carrie M. Barton, *Instr. Free-Hand Drawing and Wood Carving.*
 A. W. Williams, *Foreman Farm.*
 W. H. Murphy, *Foreman Gardens.*
 A. C. Solberg, *Instr. Wood Shop Work and Mech. Drawing.*
 Marcus Johnson, *Instr. Forging and Engin., and Steam Fitter.*
 Lilla A. Harkins, B. S., *Domestic Economy.*

TENNESSEE.

State Agricultural and Mechanical College of the University of Tennessee
Knoxville.

COURSES OF STUDY.

The courses of study are seven: General course, course in agriculture, course in civil engineering, course in mechanical engineering, course in electrical engineering, course in mining engineering, and course in pedagogy. The degrees of B. A. and B. S. are conferred.

BOARD OF INSTRUCTION.

- C. W. Dabney, jr., PH. D., LL. D., *Pres.**
 W. W. Carson, C. E., *Civil Engin.*
 F. Lamson-Scribner, B. S., *Bot. and Hort.*
 C. E. Wait, C. E., M. E., *Chem.*
 T. W. Jordan, M. A., *Latin.*
 J. B. Henneman, M. A., PH. D., *English and German.*
 C. F. Vanderford, *Agr.*
 L. D. Tyson, 1st Lieut. 9th Infantry, U. S. A., *Military Science and Tactics.*
 T. C. Karns, M. A., *History, Philosophy and Pedagogy.*
 C. D. Schmitt, M. A., *Math.*
 G. F. Mellen, PH. D., *Greek and French.*
 Charles A. Perkins, PH. D., *Physics and Elect. Engin.*
 S. M. Bain, B. S., *Instr. Geol. and Bot.*
 J. R. McColl, B. S., *Instr. Mech. and Supt. Shops.*
 R. L. Watts, B. A., *Instr. Bot. and Hort.*
 Charles Ferris, B. S., *Asst. in Drawing.*
 E. Ragland, B. S., *Instr. Math.*
 A. B. Wegener, *Instr. Physical Culture.*
 E. Wiley, B. S., *Lib.*
 J. M. Black, B. A., *Instr. English.*
 H. T. Livingston, *Instr. Latin.*

TEXAS.

State Agricultural and Mechanical College of Texas, College Station.

COURSES OF STUDY.

The courses of study are two, each extending through four years: The agricultural course, leading by specialization of studies either to the degree of B. S. H. or to the degree of B. S. A., and the mechanical course, leading in a similar way to the degree of B. C. E. or to the degree of B. M. E. Post graduate and special courses are also provided.

* On leave.

BOARD OF INSTRUCTION.

L. S. Ross, <i>Pres.</i>	J. M. Carson, <i>Agr.</i>
R. H. Whitlock, M. E., <i>Mech. Engin.</i>	P. S. Tilson, M. S., (<i>Asst.</i>) <i>Chem.</i>
J. H. Connell, M. Sc., <i>Agr.</i>	R. H. Price, B. S., <i>Hort. and Bot.</i>
H. H. Harrington, M. S., <i>Chem. and Min.</i>	H. Ness, B. S., (<i>Asst.</i>) <i>Hort. and Bot.</i>
C. Puryear, M. A., C. E., <i>Math.</i>	D. W. Spence, B. Sc., C. E., (<i>Asst.</i>) <i>Civil Engin. and Physics.</i>
T. C. Bittle, M. A., Ph. D., <i>Languages.</i>	Robert T. Bray, M. E., C. E., (<i>Asst.</i>) <i>Mech. Engin.</i>
B. C. Morse, 1st Lieut. 18th Infantry, U. S. A., <i>Military Science and Commandant.</i>	J. Clayton, (<i>Assoc.</i>) <i>Agr.</i>
Mark Francis, D. V. M., <i>Vet. Science.</i>	A. C. Gillespie, M. D., <i>Surgeon.</i>
F. E. Giesecke, M. E., <i>Drawing.</i>	J. H. Carter, <i>Sec.</i>
J. C. Nagle, B. S., M. A., C. E., <i>Civil Engin. and Physics.</i>	E. W. Hutchinson, B. C. E., <i>Bookkeeper.</i>
C. W. Hutson, <i>English and History.</i>	Bernard Sbisá, <i>Steward.</i>
R. F. Smith, (<i>Assoc.</i>) <i>Math.</i>	C. A. Lewis, <i>Foreman Carpenter Shop.</i>
D. Adriance, M. S., (<i>Assoc.</i>) <i>Chem.</i>	J. W. Carson, B. Sc., <i>Foreman Farm.</i>
A. L. Banks, B. Sc., (<i>Adjunct</i>) <i>Math.</i>	Jas. B. Watts, <i>Stockman.</i>
W. B. Philpott, M. S., (<i>Assoc.</i>) <i>English and History.</i>	

Prairie View State Normal School. *Prairie View.*

COURSE OF STUDY.

The course in agriculture requires two years for completion.

BOARD OF INSTRUCTION.

S. C. Anderson, M. A., *Prin.*

Assistants.

C. W. Lieckie, B. A.	J. H. Reed, B. A.
M. H. Brogles.	Paul Bledsoe.
J. D. Johns.	E. A. Daule.
Leonora Arvy.	W. B. Woodruff, B. S.
E. H. Holmes.	Harriet F. Kimbro.

UTAH.**Agricultural College of Utah, *Logan.***

COURSE OF STUDY.

The college work includes five distinctive lines of instruction: Course in agriculture, course in domestic arts, course in mechanic arts, course in civil engineering, business course. There are four special courses: A two years' course in agriculture, a two years' course in domestic arts, a course in mining engineering, a course in irrigation engineering, and a preparatory department. In addition to these special courses there have been organized two courses of winter lectures covering ten weeks each: A course of agricultural lectures and a course of lectures for the domestic arts department. The courses in mechanical and in mining and irrigation engineering will be post-graduate courses of one year each.

BOARD OF INSTRUCTION.

J. W. Sanborn, B. S., <i>Pres.; Agr.</i>	E. J. MacEwan, M. A., <i>English and Modern Languages.</i>
E. S. Richman, M. S. A., <i>Hort. and Bot.</i>	James Dryden, <i>Instr. Commercial Dept.</i>
Abby L. Marlatt, M. S., <i>Domestic Economy.</i>	E. A. Little, B. Sc., <i>Instr. Sewing.</i>
J. M. Sholl, B. M. E., <i>Mech. Engin.</i>	Clara Kenyon, <i>Elocution; Lib.</i>
J. T. Caine, jr., <i>Instr. Preparatory Dept.</i>	F. W. Brewer, M. A., M. D., <i>Biol.</i>
A. A. Mills, B. S., <i>Agr.</i>	J. W. Mayo, <i>Shopwork and Drawing.</i>
S. S. Twombly, M. S., D. V. S., <i>Chem. and Vet. Science.</i>	H. D. Styer, 1st Lieut. 13th Infantry, U. S. A., <i>Military Science and Math.</i>
F. B. Linfield, B. S. A., <i>Animal Husbandry and Dairying.</i>	S. Fortier, B. S. A., C. E., <i>Civil and Hydraulic Engin.</i>
J. E. Shepard, <i>Prin. Commercial Dept.</i>	Alex. Lewis, <i>Vocal Music.</i>
Mrs. S. A. Eddy, <i>Instr. Preparatory Dept.</i>	
L. S. Throop, <i>Instr. Music.</i>	

VERMONT.

University of Vermont and State Agricultural College, Burlington.

COURSES OF STUDY.

In the department of agriculture the courses of study are four; the agricultural course requiring four years and leading to a degree; the short course in agriculture requiring two years; the special course of one year, and the dairy-school course occupying six weeks.

BOARD OF INSTRUCTION.

M. H. Buckham, D. D., <i>Pres.; Polit. and Social Philosophy.</i>	L. J. Huff, <i>Modern Languages.</i>
V. G. Barbour, Ph. B., C. E., <i>Civil Engin.</i>	H. E. Tutherly, Capt. 1st Cavalry, U. S. A., <i>Military Tactics.</i>
G. H. Perkins, Ph. D., <i>Natural History.</i>	F. M. Corse, <i>Instr. Math.</i>
J. K. Chickering, M. A., <i>English Language and Literature and Elocution.</i>	L. R. Jones, Ph. B., (<i>Assoc.</i>) <i>Natural History.</i>
N. F. Merrill, Ph. D., <i>Chem.</i>	J. L. Hills, B. S., <i>Instr. Chem.</i>
A. L. Daniels, D. S., <i>Math. and Physics.</i>	A. W. Ayer, <i>Instr. Mech. Engin.</i>
J. W. Votey, C. E., <i>Civil Engin.</i>	F. A. Rich, <i>Instr. Vet. Science.</i>
Horatio Loomis, D. Sc., <i>Min.</i>	H. B. Chittenden, M. A., <i>Instr. English.</i>
A. G. Gulley, <i>Agr. and Hort.</i>	

VIRGINIA.

Virginia Agricultural and Mechanical College, Blacksburg.

COURSES OF STUDY.

The courses of study are seven, each requiring four years for completion and leading to the degree of B. S.: Agricultural course, horticultural course, applied chemistry course, general science course, civil engineering course, mechanical engineering course, and electrical engineering course. There are also two courses which require two years for completion and lead to a certificate of practical agricultural and practical mechanics.

BOARD OF INSTRUCTION.

- | | |
|--|---|
| J. M. McBryde, PH. D., LL. D. <i>Pres.; Agr. Chem.</i> | R. J. Davidson, M. A., <i>Anal. Chem.</i> |
| L. S. Randolph, M. E. (<i>Acting</i>) <i>Mech. Engin.</i> | E. P. Niles, D. V. M., <i>Vet. Science.</i> |
| W. B. Alwood, <i>Hort., Ent. and Myc.</i> | W. W. Hurt, <i>Sec.; Instr. Math. and Book-keeping.</i> |
| E. E. Sheib, PH. D., <i>English, History and Polit. Economy.</i> | W. N. Cunningham, <i>Instr. Machine Work.</i> |
| E. A. Smyth, jr., M. A., <i>Biol.</i> | J. R. Parrott (<i>Acting</i>) <i>Instr. Woodwork.</i> |
| T. P. Campbell, M. A., <i>Modern Languages.</i> | T. L. Watson, <i>Instr. Min. and Geol.</i> |
| S. R. Pritchard, M. A., (<i>Adjunct</i>) <i>Physics and Elect. Engin.</i> | J. Gardner, <i>Treas.</i> |
| R. C. Price, <i>Chem., Min. and Geol.</i> | A. W. Drinkard, B. S., <i>Asst. in English and History.</i> |
| D. O. Nourse, B. S., <i>Agr.</i> | W. O. Frith, B. S., <i>Asst. in Hort.</i> |
| J. A. Harman, 2d Lieut. 7th Cavalry, U. S. A., <i>Military Science and Tactics; (Adjunct) Math. and Physics.</i> | J. W. Stull, B. S., <i>Asst. in Math.</i> |
| | R. E. Wright, B. S., <i>Asst. in Mech. Engin.</i> |

Hampton Normal and Agricultural Institute, Hampton.

COURSE OF STUDY.

The course of study requires three years for completion and leads to no degree.

BOARD OF INSTRUCTION.

- | | |
|---|---|
| H. B. Frissell, D. D., <i>Prin.; Mental Philosophy.</i> | Alice M. Bacon, <i>Civil Government and Polit. Economy.</i> |
| H. B. Turner, <i>Pastor; Bible lessons.</i> | Catherine Condell, <i>Training.</i> |
| Geo. F. Peabody, <i>Treas. (New York).</i> | Jessie F. Andrus, <i>Grammar and Physiology.</i> |
| F. Chichester, <i>Asst. Treas. (Hampton).</i> | Mary R. Hamlin, <i>Geography.</i> |
| F. C. Briggs, <i>Business Agent.</i> | Cora Moore, <i>English.</i> |
| Albert Howe, <i>Supt. of Industries.</i> | Mary Gray Clark, <i>English.</i> |
| Martha M. Waldron, M. D., <i>Resident Physician.</i> | Emma Johnston, <i>Arithmetic.</i> |
| Leonora E. Herron, <i>Lib.</i> | Mary W. Nettleton, <i>Methods.</i> |
| Emily Herron, <i>Asst. Lib.</i> | Pearl F. Pond, <i>Drawing.</i> |
| Elizabeth Clark, <i>Lady Principal; Mathematics.</i> | Annie Beecher Scoville, <i>Bible and History.</i> |
| Elizabeth Hyde, <i>in charge of Academic Dept.</i> | Bernette Bachelder, <i>Arithmetic.</i> |
| Josephine E. Richards, <i>in charge of Indian Dept.</i> | Bessie Cleveland, <i>Music.</i> |
| C. L. Goodrich, <i>Agr.</i> | Flora F. Lowe, <i>Arithmetic and Grammar.</i> |
| C. C. Tucker, <i>Manual Training</i> | C. Gussie Adams, <i>Reading, Language and Arithmetic.</i> |
| Helen W. Ludlow, <i>Rhetoric and Composition.</i> | Alice I. Boardman, <i>Reading and Arithmetic.</i> |
| Dora Freeman, <i>Reading and Literature.</i> | Rosa M. Kidd, <i>Reading and Arithmetic.</i> |
| Myrtilla J. Sherman, <i>Grammar and Composition.</i> | Marian Metcalf, <i>Bible and Reading.</i> |
| Jane E. Davis, <i>Science.</i> | Fannie E. Pierson, <i>Science and Language.</i> |
| Jane S. Worcester, <i>History and Geography.</i> | Louise H. Armstrong, <i>Geography.</i> |
| | Grace E. Howes, <i>Physical Culture.</i> |
| | M. A. Price, Clara Snow, Louise Cleveland, and Ora Brown, <i>Indian teachers (distinctively).</i> |

WASHINGTON.

Washington Agricultural College and School of Science, Pullman.

COURSES OF STUDY.

The courses of study are ten: The course in agriculture, the course in mechanic arts, the course in pharmacy, the course in chemistry, the course in domestic economy, the course in mining engineering, the course in civil engineering, the course in mechanical engineering, the course in electrical engineering, and the course in assaying.

BOARD OF INSTRUCTION.

E. A. Bryan, M. A., <i>Pres.; History and Polit. Science.</i>	A. R. Saunders, M. E., <i>Mech. Engin. and Physics.</i>
E. R. Lake, M. S., <i>Agr., Hort. and Forestry.</i>	O. L. Waller, Ph. M., <i>Math. and Civil Engin.</i>
Nancy L. Van Doren, <i>Preceptress and Lib.; English Literature.</i>	Elton Fulmer, M. A., <i>Chem.</i>
C. V. Piper, B. S., <i>Bot. and Zoöl.</i>	L. C. Read (<i>Asst.</i>) <i>Hort.</i>
James Ferguson, <i>Sec.; Sten. and Typewriting.</i>	F. T. Dow, B. M. E. (<i>Asst.</i>) <i>Mech. Engin.</i>
	G. H. Watt, B. S., <i>Prin. Preparatory Dept.</i>
	Annie Howard <i>Asst. in Preparatory Dept.</i>

WEST VIRGINIA.

West Virginia University, Morgantown.

COURSES OF STUDY.

The courses of study are five, each requiring four years for completion: Classical course leading to the degree of B. A.; scientific course, leading to the degree of B. S.; course in mechanical engineering, leading to the degree of B. S. M. E.; course in civil engineering, leading to the degree B. S. C. E.; and course in agriculture, leading to the degree of B. Agr. There is also a department of law, in which the degree of LL. B. is given. Post-graduate work and preparatory work are also provided.

BOARD OF INSTRUCTION.

P. B. Reynolds, D. D., <i>Acting Pres.; Metaphysics and English.</i>	F. D. Ramsey, Lieut. 9th Infantry, U. S. A., <i>Military Science and Tactics.</i>
B. C. Alderson, M. A., <i>Ancient Languages and Literature.</i>	J. L. Johnston, C. E., <i>Civil Engin.</i>
J. I. Harvey, M. A., Ph. D., <i>Modern Languages and Literature.</i>	F. W. Rane, M. S., <i>Agr.</i>
T. C. Miller, M. A., <i>Prin. Preparatory Dept.</i>	W. S. Aldrich, M. E., <i>Mech. Engin. and Mech. Arts.</i>
St. G. T. Brooke, LL. D., <i>Common and Statute Law.</i>	R. A. Armstrong, M. A., <i>Math.</i>
W. P. Willey, M. A., <i>Equity Jurisprudence.</i>	S. B. Brown, M. A., <i>Geol.</i>
A. R. Whitehill, Ph. D., <i>Chem. and Physics.</i>	W. F. Reynolds, M. A., (<i>Asst.</i>) <i>Metaphysics and English.</i>
J. W. Hartigan, M. A., M. D., D. Sc., <i>Biol.</i>	A. J. Hare, B. A., <i>Asst. in Preparatory Dept.</i>
	Clara Hough, <i>Lib.</i>

The West Virginia Colored Institute, *Farm.*

COURSES OF STUDY.

The courses of study are three: A course in agriculture, requiring three years for completion; a mechanical course, and a normal course.

BOARD OF INSTRUCTION.

J. Edwin Campbell, PH. B., <i>Prin. ; Math.</i>	Mrs. J. Edwin Campbell, <i>Instr. Music,</i>
J. H. Hill, <i>English Language.</i>	<i>Painting and Drawing.</i>
J. M. Canty, jr., <i>Mech.</i>	T. C. Friend, <i>Farmer.</i>

WISCONSIN.

College of Agriculture of the University of Wisconsin, *Madison.*

COURSES OF STUDY.

The long course requires four years, leading to the degree of B. Agr. The short course in agriculture lasts twelve weeks. The dairy course lasts twelve weeks, with two seasons actual practice in factory, on satisfactory completion of which a dairy certificate is granted.

BOARD OF INSTRUCTION.

Charles K. Adams, LL. D., <i>Pres.</i>	W. G. Clark, V. S., <i>Vet. Science.</i>
W. A. Henry, B. AGR., <i>Dean ; Agr.</i>	J. W. Decker, B. AGR., <i>Instr. Cheese-</i>
S. M. Babcock, PH. D., <i>Agr. Chem.</i>	<i>making.</i>
F. H. King, <i>Agr. Physics.</i>	H. J. Noyes, <i>Instr. Butter-making.</i>
E. S. Goff, <i>Hort. and Economic Ent.</i>	E. H. Hageman, <i>Instr. at Separators.</i>
H. L. Russell, PH. D., <i>Bact.</i>	F. Walker, <i>Instr. at Separators.</i>
F. W. Woll, M. S., <i>Chem.</i>	W. E. Doane, <i>Instr. at Butter-worker.</i>
J. A. Craig, B. S. A., <i>Animal Husbandry.</i>	J. E. Knott, <i>Instr. Cheese-making.</i>
C. I. King, <i>Instr. Practical Mech.</i>	F. Wismer, <i>Instr. Cheese-making.</i>
A. W. Richter, M. E., <i>Instr. Dairy Engin.</i>	E. J. Bennett, <i>Instr. Farm Dairying.</i>
	T. A. Stanley, <i>Instr. Farm Bookkeeping.</i>

WYOMING.

College of Agriculture of the University of Wyoming, *Laramie.*

COURSE OF STUDY.

The course of study in the department of agriculture requires four years for completion, and leads to the degree of B. Agr.

BOARD OF INSTRUCTION.

A. A. Johnson, M. A., D. D., <i>Pres. ; Polit.</i>	L. C. Colburn, B. S., <i>Mech. Engin. and Math.</i>
<i>Science.</i>	E. C. Bullock, 1st Lieut. 7th Cavalry, U.
J. D. Conley, PH. D., <i>Physics and Geol.</i>	<i>S. A., Military Science and Tactics, and</i>
Aven Nelson, M. S., M. A., <i>Biol.</i>	<i>Math.</i>
E. I. Antrim, PH. D., <i>Rhetoric and English</i>	E. E. Slosson, M. S., <i>Chem.</i>
<i>Literature.</i>	Cora M. McDonald, M. A., <i>Instr. History.</i>
B. C. Buffum, M. S., <i>Bot and Hort.</i>	F. J. Niswander, B. S., <i>Ent., Zool. and Agr.</i>

OFFICERS OF THE ASSOCIATION OF AMERICAN AGRICULTURAL COL-
LEGES AND EXPERIMENT STATIONS.

President,

S. D. LEE, of Mississippi.

Vice-Presidents,

G. E. MORROW, of Illinois; H. HADLEY, of New Mexico;
J. S. NEWMAN, of South Carolina; J. H. CANFIELD, of Nebraska;
WILLIAM FREAR, of Pennsylvania.

Secretary and Treasurer,

M. A. SCOVELL, of Kentucky.

Bibliographer,

S. W. JOHNSON, of Connecticut.

Executive Committee,

The PRESIDENT; the JUNIOR EX-PRESIDENT, (W. A. HENRY, of Wisconsin); the
SECRETARY;

H. E. ALVORD, of the District of Colum- H. C. WHITE, of Georgia;
bia; A. W. HARRIS, of Maine;
H. H. GOODELL, of Massachusetts.

Chairmen of Sections,

Agriculture and Chemistry, W. A. HENRY, College work, GEO. T. FAIRCHILD, of
of Wisconsin; Kansas;
Botany and Horticulture, E. S. GOFF, of Entomology, H. OSBORN, of Iowa;
Wisconsin; Mechanic Arts, J. H. WASHBURN, of
Rhode Island.

Secretaries of Sections,

Agriculture and Chemistry, E. B. VOOR- College work, H. E. STOCKBRIDGE, of
HEES, of New Jersey; North Dakota;
Botany and Horticulture, L. H. PAMMEL, Entomology, C. M. WEED, of New
of Iowa; Hampshire;
Mechanic Arts, F. P. ANDERSON, of Kentucky.

OFFICERS AND REPORTERS OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS OF THE UNITED STATES.

President,

E. B. VOORHEES, of New Jersey.

Vice-President,

H. A. HUSTON, of Indiana.

Secretary and Treasurer,

H. W. WILEY, of the U. S. Department of Agriculture.

Executive Committee,

The PRESIDENT; the VICE-PRESIDENT; the SECRETARY;
B. B. ROSS, of Alabama; C. D. WOODS, of Connecticut.

Reporters,

Phosphoric acid, B. W. KILGORE, of North Carolina;	Foods and feeding stuffs, H. J. PATTER- SON, of Maryland;
Nitrogen, J. M. BARTLETT, of Maine;	Fermented liquors, C. A. CRAMPTON, of Washington, D. C.;
Potash, H. J. WHEELER, of Rhode Island;	Sugar, G. L. SPENCER, of the U. S. Department of Agriculture.
Soils and ash, A.M. PETER, of Kentucky;	
Dairy products, E.H. FARRINGTON, of Illinois.	

Abstract Committee,

WILLIAM FREAR, of Pennsylvania; W. C. STUBBS, of Louisiana;
E. W. HILGARD, of California; W. D. BIGELOW, of Washington, D. C.;
JOHN P. STREET, of New Jersey.

LIST OF STATION PUBLICATIONS RECEIVED AT THE OFFICE OF EXPERIMENT STATIONS DURING 1892 AND 1893.*

ALABAMA COLLEGE STATION.

Date.	Publication.	Title.
1892.		
January ...	Bulletin No. 34..	Coöperative Soil Test Experiments.
January ...	Bulletin No. 35..	Glanders.
March	Bulletin No. 36..	Some Leaf Blights of Cotton.
March	Bulletin No. 37..	Tobacco,
July	Bulletin No. 38..	Fertilizers.
November ..	Bulletin No. 39..	Wheat.
December ..	Bulletin No. 41..	Some Diseases of Cotton.
	Annual Report ..	Fifth Annual Report, 1892.
1893.		
January ...	Bulletin No. 40..	Cotton Experiments.
January ...	Bulletin No. 42..	Coöperative Soil Test Experiments.
May	Bulletin No. 43..	Eye Diseases of Domestic Animals.
May	Bulletin No. 44..	Tobacco Plant.
June	Bulletin No. 45..	Injurious and Beneficial Insects.
June	Bulletin No. 46..	Rye vs. Ensilage.
July	Bulletin No. 47..	Fruits.
July	Bulletin No. 48..	The Effect of Organic Matter on Phosphates. Commercial Fertilizers.
October ...	Bulletin No. 49..	Varieties of Wheats and Grasses.
November ..	Bulletin No. 50..	Fruit Tree Blight in General.

ALABAMA CANEBRAKE STATION.

1892.		
March	Bulletin No. 14..	Cotton.
July	Bulletin No. 15..	Cattle Feeding.
1893.		
July	Bulletin No. 16..	Potatoes—Amount of Seed.
July	Bulletin No. 17..	Grapes and Some New Fruits.

ARIZONA STATION.

1892.		
April	Bulletin No. 5...	Cañaigre.
April	Bulletin No. 6...	Soils and Waters.
	Annual Report.	Third Annual Report, 1892.
1893.		
February ..	Bulletin No. 7...	Cañaigre.
March	Bulletin No. 8...	Cattle Feeding.

ARKANSAS STATION.

1892.		
February ..	Bulletin No. 18..	Some Cotton Experiments at Newport.
May	Bulletin No. 19..	Manures and Some Principles in Farm Manuring.
November ..	Bulletin No. 20..	Animal Parasitism. Some Texas Fever Experiments.
December ..	Bulletin No. 21..	Grapes. Some Insect and Fungus Diseases and their Remedies.
		Spraying Apparatus. Apples and Grapes in Arkansas.
December ..	Bulletin No. 22..	Sorghum and Sugar-cane Culture. Syrup and Sugar-making on Small Farms. Some Field Experiments with Cantaloupes and Corn.
	Annual Report.	Fifth Annual Report, 1892.
1893.		
March	Bulletin No. 23..	Cotton.
July	Bulletin No. 24..	Fodder.

* A list of publications issued by the stations prior to January 1, 1892, was published in the Experiment Station Record, vol. III, p. 937.

CALIFORNIA STATION.

Date.	Publication.	Title.
1892.		
January ...	Bulletin No. 96.	Sulphuring in Fruit Drying. Fig Trees at the Experiment Stations. Notes on Persian Palms.
May	Bulletin No. 97..	Investigation of California Prunes, Apricots, and Peaches.
May	Bulletin No. 97.	Report of Viticultural Work During the Seasons of 1887-'89, Part I.
December..	Bulletin No. 98..	Distribution of Seeds and Plants.
December..	Bulletin No. 99..	Root Knots on Fruit Trees and Vines. A New Nozzle Tester.
	Annual Report.	Report for 1891 and 1892.
1893.		
February ..	Bulletin No. 100.	Investigation of Cattle Foods of California.
May	Bulletin No. 101.	Further examination of California Prunes, Apricots, Plums, and Nectarines.
June	Bulletin No. 102.	Analyses of Figs and Fig Soils.

COLORADO STATION.

1892.		
January ...	Special Bulletin A.	Subjects Investigated by the Experiment Station.
May	Bulletin No. 19..	Observations upon Injurious Insects.
August....	Bulletin No. 20..	The Best Milk-tester for the Practical Use of the Farmer and Dairyman. The Influence of Food upon the Pure Fat Present in Milk.
October....	Bulletin No. 21..	Sugar Beets. Irish Potatoes. Fruit Raising.
1893.		
January ...	Bulletin No. 22..	Preliminary Report on the Duty of Water.
April	Bulletin No. 23..	Colorado Weeds.
July	Bulletin No. 24..	A Few Common Insect Pests.
October....	Bulletin No. 25..	Progress Bulletin on the Loco and Larkspur.

CONNECTICUT STATE STATION.

1892.		
March	Bulletin No. 111.	Common Fungus Diseases and their Treatment.
June	Bulletin No. 112.	On the Gunning-Kjeldahl Method and a Modification Applicable in the Presence of Nitrates.
September.	Bulletin No. 113.	Fertilizers.
December ..	Bulletin No. 114.	Fertilizers.
	Annual Report.	Annual Report, 1892.
1893.		
March	Bulletin No. 115.	Common Fungus Diseases and their Treatment.
October....	Bulletin No. 116.	Fertilizers. Act Concerning Connecticut Fertilizers.

CONNECTICUT STORRS STATION.

1892.		
April	Bulletin No. 8...	Summary of the Annual Report for 1891.
November ..	Bulletin No. 9...	Soiling and Soiling Crops. Feeding Experiments with Soiling Crops.
	Annual Report.	Fifth Annual Report, 1892.
1893.		
March	Bulletin No. 10..	Results of Experiments with Fertilizers on Different Classes of Soils.
April	Bulletin No. 11..	Summary of Annual Report for 1892.

DELAWARE STATION.

1891.		
December ..	Bulletin No. 14..	Field Tests upon Indian Corn. Combating Insects by Means of Fertilizers. Notes on a Corn Crambid.
	Annual Report.	Fourth Annual Report, 1891.
1892.		
January ...	Bulletin No. 15..	Diseases of Crops and their Treatment.
March	Bulletin No. 16..	Scarlet Clover.
June	Bulletin No. 17..	Hand-power Cream Separators.
September ..	Bulletin No. 18..	Strawberries. A Strawberry Weevil.
December ..	Bulletin No. 19..	Can Peach Rot be Controlled by Spraying?
1893.		
September..	Bulletin No. 20..	Anthrax—Precautions Necessary to Prevent its Spread.
	Bulletin No. 21..	Insects Injurious to Stored Grain.

FLORIDA STATION.

Date.	Publication.	Title.
1892. January ...	Bulletin No. 16.. Bulletin No. 17.. Bulletin No. 18.. Bulletin No. 19.. Annual Report .	Corn, Hay, Weevil, Rice, Cane, Texas Blue Grass, and Cotton. Analysis of the Orange. The Horn Fly. Questions Concerning Stock Diseases. Grasses. Forage Plants. Tomato Blight. Tobacco. Annual Report, 1892.
1893. September .	Bulletin No. 20..	Soils and Fertilizers.

GEORGIA STATION.

1892. February .. March	Bulletin No. 16.. Special Bulletin No. 16½.	Cotton—Fertilizer, Culture, and Variety Tests. Announcement regarding Station Publications.
March	Bulletin No. 17..	Irish Potatoes; Sweet Potatoes; Tomatoes; Forage Plants.
July	Special Bulletin No. 17½.	The Air and the Soil in their relations to Agriculture.
October....	Circular No. 2...	Crop Report for June, 1892.
December..	Bulletin No. 18.. Bulletin No. 19.. Annual Report .	Cheese and Butter Dairying. Culture of Tobacco. Fifth Annual Report, 1892.
1893. February .. August	Bulletin No. 20.. Bulletin No. 21..	Fertilizer, Culture and Variety Experiments; Corn and Cotton. Practical Dairying; Dehorning Cattle; Feed Formulas; Experiments with Oats.

ILLINOIS STATION.

1892. February .. April	Bulletin No. 19.. Bulletin No. 20.. Bulletin No. 21..	Experiments with Oats; The Chinch Bug in Illinois. Field Experiments with Corn. Horticulture, a General Report.
May	Bulletin No. 22..	Experiments with Wheat.
August....	Bulletin No. 23..	Experiments with Oats.
November .	Annual Report .	Fifth Annual Report, 1891-'92.
1893. February .. April	Bulletin No. 24.. Bulletin No. 25.. Bulletin No. 26 .	Variations in Milk. Field Experiments with Corn. The Forest Tree Plantation.
May	Bulletin No. 27..	Some New Points in the Manipulation of the Babcock Milk Test.
September .		

INDIANA STATION.

1892. March	Bulletin No. 38..	Small Fruits; Treatment of Powdery Mildew and Black Rot; Vegetables.
April	Bulletin No. 39..	Field Experiments with Corn; Sugar Beets; Diseases of the Sugar Beet Root.
June	Bulletin No. 40..	The Silo and Silage in Indiana.
August ...	Bulletin No. 41..	Field Experiments with Wheat; Forms of Nitrogen for Wheat.
November .	Bulletin No. 42..	The Potato—The Relation of Number of Eyes on the Seed Tuber to the Product.
	Annual Report .	Fifth Annual Report, 1892.
1893. March	Bulletin No. 43..	Field Experiments with Corn; The Sugar Beet in Indiana.
May	Bulletin No. 44..	Dairy Experiments.
August ...	Bulletin No. 45..	Field Experiments with Wheat; Forms of Nitrogen for Wheat.
September .	Bulletin No. 46..	A Modification of Grandeau's Method for the Determination of Humus. Determination of Crude Fiber.
November .	Bulletin No. 47..	Does it Pay to Shelter Milch Cows in Winter? Upon Skim Milk as a Food for Calves.

IOWA STATION.

Date.	Publication.	Title.
1892. February ..	Bulletin No. 16..	Flaxseed Meal and Oil Meal. Crop Report for the Farm Department. Varieties of Potatoes. Corn Growing. Experiments with Fungicides. What to Plant on the Home Grounds. Hints for Beginners in Dairying. Lice Affecting Domestic Animals. Sugar Beets.
May	Bulletin No. 17..	Feeding Experiments with Milch Cows, Lambs, and Hogs. Sugar Beets for Iowa. Treatments of some Fungus Diseases. Effects of Spraying on Plants and Fruit, and Notes on Insects. Ergotism.
August....	Bulletin No. 18..	Experiments with Sheep. Feeding Colts. Sweet <i>vs.</i> Sour Cream Butter. Diseases of Plants Common to Iowa Cereals. Reports on Injurious Insects. The Apple Trees and Apple Crop on the College Farm. A Separating Experiment. Experimental Creamery.
November .	Bulletin No. 19..	Experiments with New Orchard Fruits, Trees, and Plants. Report of Experiments and Studies in Entomology. The Crossing of Cucurbits. Root Crops. Corn Growing. Depth of Covering Grass Seed. Winter Wheat. Calf feeding. Hog Feeding. Soiling Crops. Hints on Cheese Making. An Automatic Acid Measure.
1893. February ..	Bulletin No. 20..	Steer Feeding. Sugar Beets in Iowa. Machinery and Methods of Spraying. Grass Leaf Hoppers. Treatment of Fungus Diseases. Treatment of Spot Diseases of the Cherry and Currant, and Potato Blight. Prevention of Corn and Oat Smut. Experiments with Mallein. Rain fall Record.
	Bulletin No. 21..	Investigations in Cheese-making. Colt Feeding. Shrinkage of Wool. Time to Cut Corn. Sweet <i>vs.</i> Ripened Cream Butter. An Aromatic Bacillus of Cheese. Some Bacteriological Work in the Dairy. Impurities of Clover Seed.

IDAHO STATION.

1892. September .	Bulletin No. 1...	Organization and Progress of work of the Experiment Station.
December..	Bulletin No. 2...	Announcement and Proposed work of the Stations.
1893. March	Bulletin No. 3...	The Application of Chemistry to the Agricultural Development of Idaho.
July	Bulletin No. 4...	Methods of Preventing Smut in Wheat and Oats. Carbon Bisulphide as a Squirrel Exterminator.

KANSAS STATION.

1892. August....	Bulletin No. 33..	Experiments with Wheat.
September.	Bulletin No. 34..	Experiments in Feeding Steers, I.
December .	Bulletin No. 35..	<i>Actinomyces Bovis</i> or "Lump Jaw" of Cattle. Some Observations upon Loco.
December .	Bulletin No. 36..	Experiments with Sorghum and Sugar Beets.
December .	Bulletin No. 37..	Experiments in Potato Culture.
	Annual report..	Fifth Annual Report, 1892.
1893. March	Bulletin No. 38..	Preliminary Report on Rusts of Grain.
August....	Bulletin No. 39..	Experiments in Feeding Steers, II.
August....	Bulletin No. 40..	Experiments in Wheat.

KENTUCKY STATION.

1892. March	Bulletin No. 38..	Vegetables; Strawberries.
March	Bulletin No. 39..	Marls.
March	Bulletin No. 40..	Some Common Pests of the Farm and Garden.
July	Bulletin No. 41..	Commercial Fertilizers.
September.	Bulletin No. 42..	Experiments with Wheat and Oats.
December..	Bulletin No. 43..	Commercial Fertilizers.
1893. January ...	Bulletin No. 44..	Bordeaux Mixture for Apple Pests.
April	Bulletin No. 45..	Field Experiments with Fertilizers on Corn, Potatoes, and Tobacco.
August....	Bulletin No. 46..	Commercial Fertilizers.

LOUISIANA STATIONS.

Date.	Publication.	Title.
1892.	Second series. Bulletin No. 13..	Sweet Potatoes.
	Bulletin No. 14..	Sugar Cane.
	Bulletin No. 15..	Report of Veterinarian.
	Bulletin No. 16..	Results of 1891 Obtained on the N. La. Experiment Station.
	Bulletin No. 17..	Results of 1891 Obtained on the State Station.
	Report.....	Geology and Agriculture—a Preliminary Report upon the Hills of Louisiana. Part I.
	Bulletin No. 18..	Analysis of Commercial Fertilizers and Other Substances Useful to Agriculture.
	Bulletin No. 19..	Forage Crops, Grasses, Clovers and Small Grains.
	Annual Report	Fifth Annual Report, 1892.
1893.		
January...	Bulletin No. 20..	Tobacco Growing in Louisiana with Results of Experiments at Calhoun.
February..	Bulletin No. 21..	Report of Results for 1892 at Calhoun.
	Bulletin No. 22..	Results of the year 1892.
	Special Bulletin	The Orange and other Citrus Fruits.
	Report.....	Geology and Agriculture—a Preliminary Report upon the Hills of Louisiana. Part II.

MAINE STATION.

1892.	Annual Report Bulletin No. 4.. Report.....	Annual Report for 1892, Parts I, II, III, and IV. Testing Cream and Milk; Fat Test and Lactometer. Director's Report for 1892.
-------	--	--

MARYLAND STATION.

1892.		
January...	Special Bulletin F.	Agricultural Outlook for Maryland.
February..	Special Bulletin G.	Commercial Fertilizers.
March.....	Bulletin No. 16..	Wheat Insects.
July.....	Special Bulletin H.	Government Direction of Agriculture in Europe.
August....	Special Bulletin I.	Commercial Fertilizers.
June.....	Bulletin No. 17..	Strawberries and Seed Potatoes.
October....	Bulletin No. 18..	Sweet Potatoes.
December..	Bulletin No. 19..	Tomatoes.
	Annual Report	Fifth Annual Report, 1892.
1893.		
March.....	Bulletin No. 20..	The Composition and Digestibility of the Different Parts of Corn Fodder.
June.....	Special Bulletin K.	Commercial Fertilizers.
June.....	Bulletin No. 21..	Soils of Maryland.
September.	Bulletin No. 22..	Steer Feeding—A Well-Balanced <i>vs.</i> a Poorly-Balanced Ration.

MASSACHUSETTS STATE STATION.

1891.		
May.....	Circular	Commercial Fertilizers.
1892.		
January...	Circular	Analyses of Concentrated Feeding Stuffs and Commercial Fertilizers.
March....	Circular	Commercial Fertilizers.
June.....	Bulletin No. 42..	Feeding Experiments with Milch Cows.
August....	Bulletin No. 43..	Weather Observations. Winter Feeding Experiments with Lambs, Miscellaneous Analyses of Materials Used for Manurial Purposes. Analyses of Licensed Commercial Fertilizers.
October....	Bulletin No. 44..	Meteorological Summary for August and September. Feeding Experiments with Steers.
November.	Bulletin No. 45..	On Fodder Articles and Fodder Supplies.
	Annual Report	Tenth Annual Report, 1892.
1893.		
March.....	Bulletin No. 46..	Commercial Fertilizers.
May.....	Bulletin No. 47..	Meteorological Summary, January to April. Feeding Experiments with Pigs. Miscellaneous Analyses of Feeding Stuffs.
May.....	Circular	Commercial Fertilizers.
June.....	Bulletin No. 48..	Meteorological Summary, May and June.
August....	Bulletin No. 49..	Meteorological Summary for July.
October...	Bulletin No. 50..	Meteorological Summary, August and September.

MASSACHUSETTS HATCH STATION.

Date.	Publication.	Title.
1890.	Annual Report.	Third Annual Report, 1890.
1891.	Annual Report.	Fourth Annual Report, 1891.
1892.		
January ...	Bulletin No. 16..	A Brief Summary of Results in Electroculture.
April	Bulletin No. 17..	Experiments with Fungicides and Insecticides. Notes on Grapes, Peaches, and Siberian Crab Apples.
April	Bulletin No. 18..	Soil Tests with Fertilizers. Experiments with Different Crops.
May	Bulletin No. 19..	Report on Insects.
January-December.	Meteorological bulletins.	Meteorological Bulletins Nos. 37-48.
	Annual Report..	Fifth Annual Report, 1892.
1893.		
January ...	Bulletin No. 20..	Report on Insects.
April	Bulletin No. 21..	Report on Fruits.
January-November.	Meteorological bulletins.	Meteorological Bulletins Nos. 49-59.

MICHIGAN STATION.

1892.		
January ...	Bulletin No. 79..	Vegetable Tests.
January ...	Bulletin No. 80..	Fruits.
March	Bulletin No. 81..	Fruit Notes.
March	Bulletin No. 82..	Sugar Beets.
April	Bulletin No. 83..	Insecticides and Fungicides.
April	Bulletin No. 84..	Roots vs. Silage for Fattening Lambs.
April	Bulletin No. 85..	Potato Tests.
July	Bulletin No. 86..	Fertilizer Analyses.
September.	Bulletin No. 87..	Smut in Oats and Wheat—Jensen or Hot Water Treatment.
December.	Bulletin No. 88..	Fruit Report.
December..	Bulletin No. 89..	Conformation of Horse Governing Selection.
	Annual Report .	Fifth Annual Report, 1892.
1893.		
February ..	Bulletin No. 90..	Vegetable Tests.
February .	Bulletin No. 91..	Two Plants for Sandy Land—Spurry (<i>Spergula arvensis</i>) and Flat Pea (<i>Lathyrus sylvestris</i>).
March	Bulletin No. 92..	Small-Fruit Notes; Spraying.
April	Bulletin No. 93..	Potatoes.
April	Bulletin No. 94..	Birds of Michigan.
April	Bulletin No. 95..	Potatoes.
July	Bulletin No. 96..	Honey Analyses.
July	Bulletin No. 97..	Fertilizer Analyses.
July	Bulletin No. 98..	Locusts. The Horn-fly.
July	Bulletin No. 99..	Michigan Soils.

MINNESOTA STATION.

1892.		
March	Bulletin No. 19..	Dehorning. Cream Raising; Cheese Making; The Babcock Test.
May	Bulletin No. 20..	Fertilizers. Improvement of Timothy; Rape in Minnesota; Peas and Oats; Field Peas.
June	Bulletin No. 21..	Sugar Beets. Sorghum.
August	Bulletin No. 22..	Comparison of Different Foods for Pigs.
September.	Bulletin No. 23..	Wheat—Milling and Baking tests; Cooperative Tests with Selected Seed Wheat. The Frit Fly—a preliminary Report upon an Insect Injurious to Wheat.
October....	Bulletin No. 24..	Ornamental and Timber Trees, Shrubs and Herbaceous Plants in Minnesota.
December .	Bulletin No. 25..	Report on Small Fruit; Renewing Old Strawberry Beds; Shading Strawberry Beds; Seedling Fruits; Analyses of Grapevines.
	Biennial Report	Biennial Report, 1891-'92.
1893.		
January ...	Bulletin No. 26..	Digestion Experiments with Cows and Pigs.
February...	Bulletin No. 27..	The Composition of Fodders, Wheat, and Mill Products; The Composition of Dairy Products. Sugar Beets.
March	Bulletin No. 28..	The Classification of Insects and their Relation to Agriculture.

MISSISSIPPI STATION.

Date.	Publication.	Title.
1892.		
January ...	Bulletin No. 18..	Varieties of Cotton.
January ...	Bulletin No. 19..	The Southern Tomato Blight.
February ...	Bulletin No. 20..	Grasses and Forage Plants.
June	Bulletin No. 21..	Insects Injurious to the Cabbage. A New Method For Testing Milk; Feeding for Milk and Butter.
September ..	Bulletin No. 22..	Grapes.
December ..	Technical Bulletin No. 1.	A Chemical Study of the Cotton Plant.
	Annual Report..	Fifth Annual Report, 1892.
1893.		
February ..	Bulletin No. 23..	Varieties of Cotton.
February ..	Bulletin No. 24..	Fertilizers for Cotton.
June	Bulletin No. 25..	Colic in Horses and Mules.
August	Bulletin No. 26..	Small Fruits.

MISSOURI STATION.

1892.		
January ...	Bulletin No. 17..	Sugar Beets.
August ...	Bulletin No. 18..	Strawberries.

NEBRASKA STATION.

1892.		
March	Bulletin No. 21..	Experiments in the Culture of the Sugar Beet in Nebraska.
October	Bulletins Nos. 22 and 23.	The Corn-Fodder Disease in Cattle and Other Farm Animals, with Special Relation to Contagious Pleuro-pneumonia in American Beeves in England.
September ..	Bulletin No. 24..	Notes on Certain Caterpillars Attacking Sugar Beets.
December ..	Bulletin No. 25..	Detasseling Corn.
	Annual Report..	Sixth Annual Report, 1892.
1893.		
March	Bulletin No. 26..	Meteorological Observations for 1892.
March	Bulletin No. 27..	Experiments in the Culture of Sugar Beets in Nebraska.
March	Bulletin No. 28..	Southern Cattle Plague.
April	Bulletin No. 29..	Cost of Farm Crops.
October	Bulletin No. 30..	The Influences of Changes of Food and Temperature on the Quality and Quantity of Milk of Dairy Cows.

NEVADA STATION.

1892.		
January ...	Bulletin No. 15..	Dodder.
April	Bulletin No. 16..	The Creamery Industry.
July	Bulletin No. 17..	The Woolly Aphis of the Apple.
November ..	Bulletin No. 18..	Cheese and its Manufacture.
December ..	Bulletin No. 19..	Sugar Beets.
	Annual Report..	Fifth Annual Report, 1892.
1893.		
March	Bulletin No. 20..	Potatoes. Tobacco.
September ..	Bulletin No. 21..	Nevada Weeds.

NEW HAMPSHIRE STATION.

1890.		
	Annual Report.	Third Annual Report, 1890.
1891.		
	Annual Report.	Fourth Annual Report, 1891.
1892.		
September ..	Bulletin No. 16.	Effect of Food on composition of Butter Fat. Common Feeding Stuffs, Various Oils used in Rations.
October	Bulletin No. 17.	Stock-feeder's Guide, with Chart for use in barn,

NEW JERSEY STATIONS.

Date.	Publication.	Title.
1892.		
April	Bulletin No. 86..	Spraying for Insect and Fungus Pests of the Orchard and Vineyard.
April	Special Bulletin O.	Experiments with Nitrate of Soda upon Tomatoes.
April	Special Bulletin P.	Experiments with Fertilizers upon White and Sweet Potatoes.
April	Bulletin No. 87..	Analyses of Commercial Feeds.
April	Special Bulletin Q.	Some Fungus Diseases of the Celery.
July	Bulletin No. 88..	Analyses of Home Mixtures and Incomplete Fertilizers.
October	Bulletin No. 89..	Analyses and Valuations of Complete Fertilizers and Ground Bone.
December	Bulletin No. 90..	Grasshoppers. Locusts. Crickets.
December	Bulletin No. 91..	Some Fungus Diseases of the Quince Fruit.
	Annual Report.	Annual Report for 1892.
1893.		
February	Bulletin No. 92..	Feeding Experiments with Horses. Dried Brewers' Grains vs. Oats.
July	Bulletin No. 93..	Analyses and Study of Home-mixed Fertilizers and Fertilizer Materials.
July	Bulletin No. 94..	Insects Injurious to Cucurbits.
September	Bulletin No. 95..	The Periodical Cicada.
October	Bulletin No. 96..	Cornstalks and Straw as Hay Substitutes.
November	Bulletin No. 97..	Analyses and Valuations of Fertilizers.

NEW MEXICO STATION.

1892.		
March	Bulletin No. 5...	Notes on Fruit Insects.
March	Bulletin No. 6...	Cereals, Forage Plants, Grasses, Clovers, Textile Plants, and Sorghums.
June	Bulletin No. 7...	Scale Insects in New Mexico.
November	Bulletin No. 8...	Experiments with Various Field Crops.
December	Bulletin No. 9...	Insecticides and their Appliances.
	Annual Report.	Third Annual Report, 1891-'92.

NEW YORK STATE STATION.

1891.		
	Annual Report.	Tenth Annual Report, 1891.
1892.	(New series.)	
January ...	Bulletin No. 38..	Oyster Shells as Food for Laying Hens.
January ...	Bulletin No. 39..	Feeding Experiments with Poultry.
March	Bulletin No. 40..	Black Knot of Plum and Cherry.
April	Bulletin No. 41..	Experiments with Fungicides.
May	Bulletin No. 42..	Analyses of Commercial Fertilizers.
June	Bulletin No. 43..	Experiments in the Manufacture of Cheese.
August	Bulletin No. 44..	Strawberries.
August	Bulletin No. 45..	Experiments in the Manufacture of Cheese.
November	Bulletin No. 46..	Experiments in the Manufacture of Cheese.
November	Bulletin No. 47..	Experiments in the Manufacture of Cheese.
December	Bulletin No. 48..	Some Bean Diseases.
1893.		
January ...	Bulletin No. 49..	Treatment of Potato Scab; Use of Bordeaux Mixture for Potato Blight.
January ...	Bulletin No. 50..	Summary of Results of Experiments made in the Manufacture of Cheese during the Season of 1892.
March	Bulletin No. 51..	Some Celery Diseases.
March	Bulletin No. 52..	Analyses of Commercial Fertilizers.
April	Bulletin No. 53..	Feeding Experiments with Capons.

NEW YORK CORNELL STATION.

1892.		
June	Bulletin No. 38..	The Cultivated Native Plums and Cherries.
July	Bulletin No. 39..	Creaming and Aërating Milk.
July	Bulletin No. 40..	Removing Tassels from Corn.
August	Bulletin No. 41..	The Comparative Merits of Steam and Hot Water for Greenhouse Heating.
September	Bulletin No. 42..	Second Report upon Electro-Horticulture.
September	Bulletin No. 43..	Some Troubles of Winter Tomatoes.
October	Bulletin No. 44..	The Pear Tree Psylla.
October	Bulletin No. 45..	Tomatoes
November	Bulletin No. 46..	Mulberries.
December	Bulletin No. 47..	Feeding Lambs and Pigs.
December	Bulletin No. 48..	Spraying Apple Orchards.
December	Bulletin No. 49..	Sundry Investigations of the Year.

NEW YORK CORNELL STATION—Continued.

Date.	Publication.	Title.
1893.		
March	Bulletin No. 50..	The Bud Moth.
April	Bulletin No. 51..	Four New Types of Fruits.
May	Bulletin No. 52..	Cost of Milk Production; Variation in Individual Cows.
May	Bulletin No. 53..	Edema of the Tomato.
June	Bulletin No. 54..	Dehorning.
July	Bulletin No. 55..	Greenhouse Notes.
August.....	Bulletin No. 56..	The Production of Manure.
September..	Bulletin No. 57..	Raspberries and Blackberries.
October....	Bulletin No. 58..	The Four-Lined Leaf Bug.

NORTH CAROLINA STATION.

1892.		
January ...	Bulletin No. 82 ..	Fertilizer Analyses and Fertilizer Control.
February]..	Bulletin No. 82a	Fertilizer Analyses.
February..	Bulletin No. 83 ..	Growing Celery in the South; Cultivation of Onions; Notes on Horticultural Work during 1891.
February ..	Bulletin No. 83a	Meteorological Summary for January.
March	Bulletin No. 83b.	Fertilizer Analyses.
March	Bulletin No. 83c.	Fertilizer Analyses.
March	Bulletin No. 83d.	Meteorological Summary for February.
April	Bulletin No. 83e.	Fertilizer Analyses.
April	Bulletin No. 84 ..	Some Enemies of Truck and Garden Crops.
April	Bulletin No. 85 ..	The Late Crop of Irish Potatoes in the South.
April	Bulletin No. 85a	Meteorological Summary for March.
May	Bulletin No. 86 ..	Tobacco Curing by the Leaf Cure on Wire and the Stalk Processes.
May	Bulletin No. 86a	Meteorological Summary for April.
June	Bulletin No. 86b.	Fertilizer Analyses.
June	Bulletin No. 86c.	Meteorological Summary for May.
July	Bulletin No. 86d.	Meteorological Summary for June.
September..	Bulletin No. 87 ..	Publications of the Station from March, 1877, to September, 1892.
August....	Bulletin No. 87a	Meteorological Summary for July.
September..	Bulletin No. 87b.	Meteorological Summary for August.
October....	Bulletin No. 87c.	Meteorological Summary for September.
November ..	Bulletin No. 87d	Digestion Experiments with Pulled Fodder, Crimson Clover Hay, Cow-pea Vine Hay, Corn Silage, Soja Bean Silage, Raw Cotton Seed, Roasted Cotton Seed, Cotton-Seed Hulls, and Cotton-Seed Meal.
November ..	Bulletin No. 87e.	Meteorological Summary for October; Brief Statement of Rules for Making Local Weather Forecasts.
December ..	Bulletin No. 87f.	Meteorological Summary for November.
	Annual Report ..	Fifteenth Annual Report for 1892.
1893.		
January ...	Bulletin No. 88 ..	Fertilizer Analyses and Fertilizer Control.
January ...	Bulletin No. 88a	Meteorological Summary for December, 1892.
	Annual Report.	Sixth Annual Report of the Meteorological Division, 1892.
February ..	Bulletin No. 88b.	Fertilizer Analyses and Fertilizer Control.
March	Bulletin No. 88c.	Fertilizer Analyses and Fertilizer Control.
March	Bulletin No. 88d.	Meteorological Summary for January.
March	Bulletin No. 89 ..	Cooperative Field Tests during 1891 and 1892.
March	Bulletin No. 89a.	Fertilizer Analyses.
March	Bulletin No. 89b.	Meteorological Summary for February.
April	Bulletin No. 90 ..	Practical Stock-Feeding.
April	Bulletin No. 90a.	Results of Chemical Analyses of Tobacco Cured by the Leaf-cure on Wire and the Stalk Processes.
April	Bulletin No. 90b.	Chemical Analyses of some Native North Carolina Grasses, Forage Plants, Grains, Seeds, and By-products.
April	Bulletin No. 90c.	Fertilizer Analyses.
April	Bulletin No. 91..	Some Experiments in Wheat Culture; Thunder Storm Observations in North Carolina, June 1 to August 31, 1893.
May	Bulletin No. 91a.	Meteorological Summary for April.
June	Bulletin No. 91b.	Fertilizer Analyses.
June	Bulletin No. 91c.	Meteorological Summary for May; the Oxford Tornado of May 3, 1893.
July	Bulletin No. 91d.	Investigations upon the Phosphoric Acid in Crude Fertilizing Materials and upon Methods of Fertilizer Analysis.
July	Bulletin No. 91e.	Meteorological Summary for June.
August....	Bulletin No. 92..	The Culture of Orchard and Garden Fruits.
August....	Bulletin No. 92a.	Meteorological Summary for July.
September ..	Bulletin No. 92b.	Meteorological Summary for August.
October ..	Bulletin No. 93a.	Meteorological Summary for September.

NORTH DAKOTA STATION.

Date.	Publication.	Title.
1892.		
February ..	Bulletin No. 5...	Sugar Beets.
June	Bulletin No. 6. .	The Mustard Family.
September..	Bulletin No. 7...	Rheumatism in Horses.
December..	Bulletin No. 8 . .	Wheat-Growing and Dairying for North Dakota.
	Annual Report .	Third Annual Report, 1892.
1893.		
March	Bulletin No. 9...	The Conditions Affecting the Value of Wheat for Seed; Prevention of Potato Scab.
May	Bulletin No. 10..	Grain and Forage Crops.
October. . .	Press Bulletin No. 1.	The Russian Cactus.

OHIO STATION.

1892.		
January ...	Bulletin Vol. V, No. 1.	Oats.
February..	Bulletin Vol. V, No. 2.	Mangel Wurzels and Sugar Beets.
March	Bulletin Vol. V, No. 3.	Field Experiments with Commercial Fertilizers.
April	Bulletin Vol. V, No. 4.	Insects which Burrow in the Stems of Wheat.
August....	Bulletin No. 42..	Field Experiments with Wheat.
September..	Bulletin No. 43..	Greenhouses and Greenhouse Work; Tomatoes and Lettuce as Greenhouse Crops. The Food of the Robin.
September..	Bulletin No. 44..	A Preliminary List of the Insects of Ohio. Wild Lettuce. A Pestiferous Weed. Wheat Scab.
December .	Bulletin No. 45..	Insects Affecting the Blackberry and Raspberry.
December .	Bulletin No. 46..	Underground Insect Destroyers of the Wheat Plant.
December .	Bulletin No. 47..	Annual Report, 1892.
1893.		
February..	Bulletin No. 48..	Profit in Spraying Orchards and Vineyards.
May	Bulletin No. 49..	Field Experiments with Commercial Fertilizers.
April	Bulletin Vol. I, No. 3 (technical series).	Entomological and Botanical Papers.

OKLAHOMA STATION.

1892.		
March	Bulletin No. 2 . .	Station work in progress.
June	Bulletin No. 3 . .	Insects and Insecticides.
October....	Special Bulletin No. 1.	Texas Cattle Fever.
October....	Bulletin No. 4...	Tests of Varieties—Oats, Corn, Spring Wheat, Irish and Sweet Potatoes.
1893.		
January ...	Bulletin No. 5...	Some Soil Analyses.
May	Bulletin No. 6...	Notes of Progress; Analyses.
November .	Press Bulletin No. 8.	Notes on Work of the Station.
December..	Press Bulletin No. 9.	Notes on Work of the Station.

OREGON STATION.

1892.		
January ...	Bulletin No. 15..	Horticulture.
February ..	Bulletin No. 16..	Notes on Varieties and Yield of Wheat.
February ..	Bulletin No. 17..	Sugar Beets.
March	Bulletin No. 18..	Insects Injurious to Young Fruit Trees—Codling Moth; Wire Worms; Flea Beetles.
May	Bulletin No. 19..	Some Oregon Weeds and How to Destroy Them.
September..	Bulletin No. 20..	Experiments in Pig Feeding.
October....	Bulletin No. 21..	Soils of Oregon.
1893.		
January ...	Bulletin No. 22..	Comparative Test of Small Fruits and Vegetables. Renovation of Old Orchards.
February ..	Bulletin No. 23..	Experiments in the Culture of the Sugar Beet in Oregon.
March	Bulletin No. 24..	Potatoes. Roots.
April	Bulletin No. 25..	Codling Moth and Hop Louse. Gophers and Moles.
May	Bulletin No. 26..	Drainage.

PENNSYLVANIA STATION.

Date.	Publication.	Title.
1891.	Annual Report .	Annual Report for 1891.
1892.		
January ...	Bulletin No. 18..	Notes on New and Old Varieties of Orchard Fruits and Small Fruits.
April	Bulletin No. 19..	Information on Spraying Fruits.
July	Bulletin No. 20..	Tests of Dairy Apparatus.
October....	Bulletin No. 21..	The Koch Test for Tuberculosis.
1893.		
January ...	Bulletin No. 22..	Tests of Dairy Apparatus.
April	Bulletin No. 23..	Forest Fires; Experience with Evergreens in Pennsylvania.
July	Bulletin No. 24..	Influence of Quantity of Food upon Economy of Milk and Butter Production.

RHODE ISLAND STATION.

1892.		
April	Bulletin No. 15..	Treatment of Loose Smut of Oats; Fungicides and Insecticides and their Use.
May	Bulletin No. 16..	The New Fertilizer Law for Rhode Island; Analyses of Commercial Fertilizers.
	Annual Report .	Fifth Annual Report, 1892.
June	Bulletin No. 17..	Analyses of Commercial Fertilizers.
August....	Bulletin No. 18..	Analyses of Commercial Fertilizers.
September..	Bulletin No. 19..	Analyses of Commercial Fertilizers.
December..	Bulletin No. 20..	Production and Market Value of Capons.
1893.		
January ...	Bulletin No. 21..	Seaweeds—their Agricultural Value; the Chemical Composition of Certain Species.
February ..	Bulletin No. 22..	Strawberries.
July	Bulletin No. 23..	Fertilizers, Commercial and Miscellaneous.
August	Bulletin No. 24..	Analyses of Commercial Fertilizers.

SOUTH CAROLINA STATION.

1892.		
July	Bulletin No. 5...	Methods of Keeping Sweet Potatoes.
July	Bulletin No. 6...	Analyses of Commercial Fertilizers.
September..	Bulletin No. 7...	Experiments with Oats and Wheat.
December..	Bulletin No. 8...	Occurrence of Phosphoric Acid in Cotton-Seed Meal.
	Annual Report .	Fifth Annual Report for 1892.

SOUTH DAKOTA STATION.

1892.		
March	Bulletin No. 30..	Report of Entomologist.
May	Bulletin No. 31..	Meteorology.
December ..	Bulletin No. 32..	Forestry.
1893.		
February ..	Bulletin No. 33..	Some Plants Injurious to Stock.
April	Bulletin No. 34..	The Sugar Beet.
May	Bulletin No. 35..	Fungus Diseases and Insect Pests.
June	Bulletin No. 36..	Scab; Lumpy Jaw; Anthrax.

TENNESSEE STATION.

1890.	Annual Report .	Third Annual Report, 1890.
1891.	Annual Report .	Fourth Annual Report, 1891.
1892.		
January ...	Bulletin Vol. V, No. 1.	Fruit Trees and Experiments with Vegetables.
April	Bulletin Vol. V, No. 2.	Grasses of Tennessee, part I.
July	Bulletin Vol. V, No. 3.	A Contribution to the Study of the Economies of Milk Production.
November .	Bulletin Vol. V, No. 4.	Experiments with Fruit Trees and Vegetables.
	Annual Report.	Fifth Annual Report, 1892.
1893.		
January ...	Bulletin Vol. VI, No. 1.	Some injurious Insects of the Apple.
April	Bulletin Vol. VI, No. 2.	Rational use of Feeding Stuffs; Winter Dairying in Tennessee.
July	Bulletin Vol. VI, No. 3.	Small Fruits; Grapes.
October....	Bulletin Vol. VI, No. 4.	Field Experiments with Tomatoes and Onions.

TEXAS STATION.

Date.	Publication.	Title.
1892.		
March	Bulletin No. 20.	Grasses and Grains; Forage Plants.
June	Bulletin No. 21.	Effect of Cotton-Seed and Cotton-Seed Meal in Feeding Hogs.
September.	Bulletin No. 22.	Alfalfa Root Rot.
November.	Bulletin No. 23.	Black Rot of the Grape.
December.	Bulletin No. 24.	The Cattle Tick.
December.	Bulletin No. 25.	Texas Soils; a Study of Chemical Composition.
	Annual Report.	Fifth Annual Report, 1892.
1893.		
March	Bulletin No. 26.	Cost of Cotton Production and Profit per Acre.
June	Bulletin No. 27.	Steer Feeding.

UTAH STATION.

1892.		
April	Bulletin No. 11.	Blanketing Horses and Cattle; Sheltered <i>vs.</i> Unsheltered Cattle; Exercise <i>vs.</i> Non Exercise for Stock.
March	Bulletin No. 12.	Experiments with Garden Vegetables.
May	Bulletin No. 13.	Feeding Hay and Grain Mixed to Horses; Feeding Cut Hay <i>vs.</i> Whole Hay to Horses.
June	Bulletin No. 14.	Horticulture and Entomology.
August	Bulletin No. 15.	Soiling Steers, or Green <i>vs.</i> Dry Food.
August	Bulletin No. 16.	The Digestibility of Green and Dry Timothy.
October	Bulletin No. 17.	Feeding Root Crops <i>vs.</i> Dry Food.
October	Bulletin No. 18.	Notes on Forest and Fruit Trees.
October	Bulletin No. 19.	Feeding Ensilage <i>vs.</i> Dry Food.
	Annual Report.	Third Annual Report, 1892.
1893.		
March	Bulletin No. 20.	Report of Horticultural Department.
March	Bulletin No. 21.	Feeding Ruminants on Grain alone. Night <i>vs.</i> Day Irrigation.
May	Bulletin No. 22.	Grass <i>vs.</i> Nongrass Fed Pigs; Exercise <i>vs.</i> Nonexercise of Pigs. Value of Natural Waters for Crop Growth.
July	Bulletin No. 23.	Shelter of Stock; Exercise <i>vs.</i> Non-exercise of Stock. Early <i>vs.</i> Late Irrigation.
August	Bulletin No. 24.	Irrigation.

VERMONT STATION.

1891.		
	Annual Report.	Fifth Annual Report, 1891.
1892.		
January ...	Bulletin No. 27.	Tests of Dairy Apparatus.
April	Bulletin No. 28.	Plant Diseases.
May	Bulletin No. 29.	Analyses of Fertilizers.
June	Bulletin No. 30.	Results of the Bounty on Maple Sugar.
	Annual Report.	Sixth Annual Report, 1892.
1893.		
February ..	Bulletin No. 31.	Feeding Tests with Sugar Meal, Cream Gluten Meal, and Germ Feed.
March	Bulletin No. 32.	Oat Smut.
April	Bulletin No. 33.	Record of the Station Herd for the year 1892.
April	Bulletin No. 34.	Analyses of Fertilizers.
May	Bulletin No. 35.	Analyses of Fertilizers.

VIRGINIA STATION.

1892.		
January ...	Bulletin No. 12.	Tests of Fertilizers on Tobacco.
February ..	Bulletin No. 13.	Antiseptic Treatment of Wounds; Infectious Abortion in Cows.
March	Bulletin No. 14.	Chemistry of the Tobacco Plant.
April	Bulletin No. 15.	Treatment of the Diseases of the Grape.
May	Bulletin No. 16.	Co-operative Corn Tests.
June	Bulletin No. 17.	Four Diseases of the Apple.
July	Bulletin No. 18.	Antiseptics in Relation to the Treatment of Wounds.
August	Bulletin No. 19.	Test of Varieties of Wheat.
September.	Bulletin No. 20.	A new Fodder Plant— <i>Lathyrus Sylvestris</i> .
October	Bulletin No. 21.	Test of Fertilizers on Wheat.
November.	Bulletin No. 22.	Bush Fruits.
December..	Bulletin No. 23.	Test of Fertilizers on Corn.
	Annual Report.	Annual Report for 1892.
1893.		
January ...	Bulletin No. 24.	Injurious Insects and Diseases of Plants, with Remedial Measures.
February ..	Bulletin No. 25.	Dorset Horn Sheep.
March	Bulletin No. 26.	Tuberculosis and the Koch Test.
April	Bulletin No. 27.	Strawberries.
May	Bulletin No. 28.	Tests of Varieties of Wheat.
June	Bulletin No. 29.	Tests of Fertilizers on Wheat.

WASHINGTON STATION.

Date.	Publication.	Title.
1892.		
January ...	Bulletin No. 2...	Report of Farmers' Institute held at Colton, Washington.
February ..	Bulletin No. 3...	Report of Farmers' Institute held at Garfield, Washington.
May	Bulletin No. 4...	Wireworms.
May	Bulletin No. 5...	Report of Farmers' Institute held at Pomeroy, Washington.
	Annual Report ..	Annual Report, 1891.
October....	Bulletin No. 6...	Horticultural Information.

WEST VIRGINIA STATION.

1892.		
January ...	Bulletin No. 20..	Potato Culture and Fertilization. Tests of Varieties of Tomatoes.
April	Bulletin No. 21..	Injurious Insects and Plant Diseases.
February ..	Bulletin No. 22..	Your Weeds and Your Neighbors, Part II.
May	Bulletin No. 23..	Your Weeds and Your Neighbors, Part III.
June	Bulletin No. 24..	Flora of West Virginia.
August....	Bulletin No. 25..	Plat Experiments with Commercial Fertilizers on Wheat.
September.	Bulletin No. 26..	Law and Regulations Concerning Sale of Commercial Fertilizers in the State of West Virginia; Analyses.
November .	Bulletin No. 27..	Notes on Pruning.
December..	Bulletin No. 28..	Plat Experiments with Commercial Fertilizers on Corn.
1893.		
January ...	Bulletin No. 29..	Experiments on Potatoes at the Station; Experiments on Corn at the Out-stations.
	Bulletin No. 30..	Sheep.
April	Bulletin No. 31..	Catalogue of West Virginia Scolytides and their Enemies.
August....	Special bulletin.	Fertilizers.

WISCONSIN STATION.

1892.		
January ...	Bulletin No. 30..	Sugar Beet Experiments.
April	Bulletin No. 31..	Notes on the Use of the Babcock Test and the Lactometer.
July	Bulletin No. 32..	Feeding Grain to Lambs.
October....	Bulletin No. 33..	Rations for Dairy Cows.
1893.		
January ...	Bulletin No. 34..	Preventive Treatment for Apple Scab, Downy Mildew, and Brown Rot of Grape, Potato Blight, and Smut of Wheat and Oats.
April	Bulletin No. 35..	Insects and Diseases Injurious to Cranberries.
July	Bulletin No. 36..	Directions for Using the Babcock Milk Test and the Lactometer.
October....	Bulletin No. 37..	The Russian Thistle.

WYOMING STATION.

1892.		
February ..	Bulletin No. 5...	Best Varieties and Breeds for Wyoming.
May	Bulletin No. 6...	Soils of the Agricultural Experiment Farms.
July	Bulletin No. 7...	Insecticides.
October....	Bulletin No. 8...	Irrigation and Duty of Water.
December .	Bulletin No. 9...	Sugar Beets in 1892.
December .	Bulletin No. 10..	Meteorology for 1892.
1893.	Annual Report ..	Annual Report for 1892.
February..	Bulletin No. 11..	Crop Report for 1892.
April	Bulletin No. 12..	Ground Squirrels (Gophers).
July	Bulletin No. 13..	The Feeding and Management of Cattle.
October....	Bulletin No. 14..	Geology of Wyoming Experimental Farm and Notes on Mineral Resources of the State.

FEDERAL LEGISLATION AFFECTING AGRICULTURAL COLLEGES AND EXPERIMENT STATIONS.

ACT OF 1862 DONATING LANDS FOR AGRICULTURAL COLLEGES.

AN ACT donating public lands to the several States and Territories which may provide colleges for the benefit of agriculture and the mechanic arts.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there be granted to the several States, for the purposes hereinafter mentioned, an amount of public land, to be apportioned to each State a quantity equal to thirty thousand acres for each Senator and Representative in Congress to which the States are respectively entitled by the apportionment under the census of eighteen hundred and sixty: *Provided,* That no mineral lands shall be selected or purchased under the provisions of this act.

SEC. 2. That the land aforesaid, after being surveyed, shall be apportioned to the several States in sections or subdivisions of sections, not less than one quarter of a section; and whenever there are public lands in a State subject to sale at private entry at one dollar and twenty-five cents per acre, the quantity to which said State shall be entitled shall be selected from such lands within the limits of such State, and the Secretary of the Interior is hereby directed to issue to each of the States in which there is not the quantity of public lands subject to sale at private entry at one dollar and twenty-five cents per acre, to which said State may be entitled under the provisions of this act, land scrip to the amount in acres for the deficiency of its distributive share; said scrip to be sold by said States and the proceeds thereof applied to the uses and purposes prescribed in this act, and for no other use or purpose whatsoever: *Provided,* That in no case shall any State to which land scrip may thus be issued be allowed to locate the same within the limits of any other State, or of any Territory of the United States, but their assignees may thus locate said land scrip upon any of the unappropriated lands of the United States subject to sale at private entry at one dollar and twenty-five cents, or less, per acre: *And provided further,* That not more than one million acres shall be located by such assignees in any one of the States: *And provided further,* That no such location shall be made before one year from the passage of this act.

SEC. 3. That all the expenses of management, superintendence, and taxes from date of selection of said lands, previous to their sales, and all expenses incurred in the management and disbursement of the moneys which may be received therefrom, shall be paid by the States to which they may belong, out of the treasury of said States, so that the entire proceeds of the sale of said lands shall be applied without any diminution whatever to the purposes hereinafter mentioned.

SEC. 4. That all moneys derived from the sale of the lands aforesaid by the States to which the lands are apportioned, and from the sales of land scrip hereinbefore provided for, shall be invested in stocks of the United States, or of the States, or some other safe stocks, yielding not less than five per centum upon the par value of said stocks; and that the moneys so invested shall constitute a perpetual fund, the capital of which shall remain forever undiminished (except so far as may be provided in section fifth of this act), and the interest of which shall be inviolably

appropriated, by each State which may take and claim the benefit of this act, to the endowment, support, and maintenance of at least one college where the leading object shall be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts, in such manner as the legislatures of the States may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life.

SEC. 5. That the grant of land and land scrip hereby authorized shall be made on the following conditions, to which, as well as to the provisions hereinbefore contained, the previous assent of the several States shall be signified by legislative acts:

First. If any portion of the fund invested, as provided by the foregoing section, or any portion of the interest thereon, shall, by any action or contingency, be diminished or lost, it shall be replaced by the State to which it belongs, so that the capital of the fund shall remain forever undiminished; and the annual interest shall be regularly applied without diminution to the purposes mentioned in the fourth section of this act, except that a sum, not exceeding ten per centum upon the amount received by any State under the provisions of this act, may be expended for the purchase of lands for sites or experimental farms, whenever authorized by the respective legislatures of said States.

Second. No portion of said fund, nor the interest thereon, shall be applied, directly or indirectly, under any pretense whatever, to the purchase, erection, preservation, or repair of any building or buildings.

Third. Any State which may take and claim the benefit of the provisions of this act shall provide, within five years, at least not less than one college, as described in the fourth section of this act, or the grant to such State shall cease; and said State shall be bound to pay the United States the amount received of any lands previously sold, and that the title to purchasers under the State shall be valid.

Fourth. An annual report shall be made regarding the progress of each college, recording any improvements and experiments made, with their costs and results, and such other matters, including State industrial and economical statistics, as may be supposed useful; one copy of which shall be transmitted by mail free, by each, to all the other colleges which may be endowed under the provisions of this act, and also one copy to the Secretary of the Interior.

Fifth. When lands shall be selected from those which have been raised to double the minimum price, in consequence of railroad grants, they shall be computed to the States at the maximum price, and the number of acres proportionally diminished.

Sixth. No State while in a condition of rebellion or insurrection against the Government of the United States shall be entitled to the benefit of this act.

Seventh. No State shall be entitled to the benefits of this act unless it shall express its acceptance thereof by its legislature within two years from the date of its approval by the President.

SEC. 6. That land scrip issued under the provisions of this act shall not be subject to location until after the first day of January, one thousand eight hundred and sixty-three.

SEC. 7. That the land officers shall receive the same fees for locating land scrip issued under the provisions of this act as is now allowed for the location of military bounty land warrants under existing laws: *Provided*, Their maximum compensation shall not be thereby increased.

SEC. 8. That the governors of the several States to which scrip shall be issued under this act shall be required to report annually to Congress all sales made of such scrip until the whole shall be disposed of, the amount received for the same, and what appropriation has been made of the proceeds.

Approved July 2, 1862.

ACT OF 1887 ESTABLISHING AGRICULTURAL EXPERIMENT STATIONS.

AN ACT to establish agricultural experiment stations in connection with the colleges established in the several States under the provisions of an act approved July second, eighteen hundred and sixty-two, and of the acts supplementary thereto.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That in order to aid in acquiring and diffusing among the people of the United States useful and practical information on subjects connected with agriculture, and to promote scientific investigation and experiment respecting the principles and applications of agricultural science, there shall be established, under direction of the college or colleges or agricultural department of colleges in each State or Territory established, or which may hereafter be established, in accordance with the provisions of an act approved July second, eighteen hundred and sixty-two, entitled "An act donating public lands to the several States and Territories which may provide colleges for the benefit of agriculture and the mechanic arts," or any of the supplements to said act, a department to be known and designated as an "agricultural experiment station:" *Provided,* That in any State or Territory in which two such colleges have been or may be so established the appropriation hereinafter made to such State or Territory shall be equally divided between such colleges, unless the legislature of such State or Territory shall otherwise direct.

SEC. 2. That it shall be the object and duty of said experiment stations to conduct original researches or verify experiments on the physiology of plants and animals; the diseases to which they are severally subject, with the remedies for the same; the chemical composition of useful plants at their different stages of growth; the comparative advantages of rotative cropping as pursued under a varying series of crops; the capacity of new plants or trees for acclimation; the analysis of soils and water; the chemical composition of manures, natural or artificial, with experiments designed to test their comparative effects on crops of different kinds; the adaptation and value of grasses and forage plants; the composition and digestibility of the different kinds of food for domestic animals; the scientific and economic questions involved in the production of butter and cheese; and such other researches or experiments bearing directly on the agricultural industry of the United States as may in each case be deemed advisable, having due regard to the varying conditions and needs of the respective States or Territories.

SEC. 3. That in order to secure, as far as practicable, uniformity of methods and results in the work of said stations, it shall be the duty of the United States Commissioner of Agriculture to furnish forms, as far as practicable, for the tabulation of results of investigation or experiments; to indicate from time to time, such lines of inquiry as to him shall seem most important; and, in general, to furnish such advice and assistance as will best promote the purpose of this act. It shall be the duty of each of said stations annually, on or before the first day of February, to make to the governor of the State or Territory in which it is located a full and detailed report of its operations, including a statement of receipts and expenditures, a copy of which report shall be sent to each of said stations, to the said Commissioner of Agriculture, and to the Secretary of the Treasury of the United States.

SEC. 4. That bulletins or reports of progress shall be published at said stations at least once in three months, one copy of which shall be sent to each newspaper in the States or Territories in which they are respectively located, and to such individuals actually engaged in farming as may request the same, and as far as the means of the station will permit. Such bulletins or reports and the annual reports of said stations shall be transmitted in the mails of the United States free of charge for postage, under such regulations as the Postmaster-General may from time to time prescribe.

SEC. 5. That for the purpose of paying the necessary expenses of conducting investigations and experiments and printing and distributing the results as hereinbefore

prescribed, the sum of fifteen thousand dollars per annum is hereby appropriated to each State, to be specially provided for by Congress in the appropriations from year to year, and to each Territory entitled under the provisions of section eight of this act, out of any money in the Treasury proceeding from the sales of public lands, to be paid in equal quarterly payments, on the first day of January, April, July, and October in each year, to the treasurer or other officer duly appointed by the governing boards of said colleges to receive the same, the first payment to be made on the first day of October, eighteen hundred and eighty-seven: *Provided, however,* That out of the first annual appropriation so received by any station an amount not exceeding one-fifth may be expended in the erection, enlargement, or repair of a building or buildings necessary for carrying on the work of such station; and thereafter an amount not exceeding five per centum of such annual appropriation may be so expended.

SEC. 6. That whenever it shall appear to the Secretary of the Treasury from the annual statement of receipts and expenditures of any of said stations that a portion of the preceding annual appropriation remain unexpended, such amount shall be deducted from the next succeeding annual appropriation to such station, in order that the amount of money appropriated to any station shall not exceed the amount actually and necessarily required for its maintenance and support.

SEC. 7. That nothing in this act shall be construed to impair or modify the legal relation existing between any of the said colleges and the government of the States or Territories in which they are respectively located.

SEC. 8. That in States having colleges entitled under this section to the benefits of this act and having also agricultural experiment stations established by law separate from said colleges, such States shall be authorized to apply such benefits to experiments at stations so established by such States; and in case any State shall have established under the provisions of said act of July second, aforesaid, an agricultural department or experimental station, in connection with any university, college, or institution not distinctively an agricultural college or school, and such State shall have established or shall hereafter establish a separate agricultural college or school, which shall have connected therewith an experimental farm or station, the legislature of such State may apply in whole or in part the appropriation by this act made to such separate agricultural college or school, and no legislature shall by contract express or implied disable itself from so doing.

SEC. 9. That the grants of moneys authorized by this act are made subject to the legislative assent of the several States and Territories to the purposes of said grants: *Provided,* That payment of such installments of the appropriation herein made as shall become due to any State before the adjournment of the regular session of its legislature meeting next after the passage of this act shall be made upon the assent of the governor thereof duly certified to the Secretary of the Treasury.

SEC. 10. Nothing in this act shall be held or construed as binding the United States to continue any payments from the Treasury to any or all the States or institutions mentioned in this act, but Congress may at any time amend, suspend, or repeal any or all the provisions of this act.

Approved, March 2, 1887.

ACT OF 1890 FOR THE FURTHER ENDOWMENT OF AGRICULTURAL COLLEGES.

AN ACT to apply a portion of the proceeds of the public lands to the more complete endowment and support of the colleges for the benefit of agriculture and the mechanic arts established under the provisions of an act of Congress approved July second, eighteen hundred and sixty-two.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there shall be, and hereby is, annually appropriated, out of any money in the Treasury not otherwise appropriated, arising from the sales of public lands, to be paid as hereinafter provided to each State and Territory for the more complete endowment and maintenance of colleges for the benefit of agri-

culture and the mechanic arts now established, or which may be hereafter established, in accordance with an act of Congress approved July second, eighteen hundred and sixty-two, the sum of fifteen thousand dollars for the year ending June thirtieth, eighteen hundred and ninety, and an annual increase of the amount of such appropriation thereafter for ten years by an additional sum of one thousand dollars over the preceding year, and the annual amount to be paid thereafter to each State and Territory shall be twenty-five thousand dollars to be applied only to instruction in agriculture, the mechanic arts, the English language and the various branches of mathematical, physical, natural and economic science, with special reference to their applications in the industries of life, and to the facilities for such instruction: *Provided*, That no money shall be paid out under this act to any State or Territory for the support and maintenance of a college where a distinction of race or color is made in the admission of students, but the establishment and maintenance of such colleges separately for white and colored students shall be held to be a compliance with the provisions of this act if the funds received in such State or Territory be equitably divided as hereinafter set forth: *Provided*, That in any State in which there has been one college established in pursuance of the act of July second, eighteen hundred and sixty-two, and also in which an educational institution of like character has been established, or may be hereafter established, and is now aided by such State from its own revenue, for the education of colored students in agriculture and the mechanic arts, however named or styled, or whether or not it has received money heretofore under the act to which this act is an amendment, the Legislature of such State may propose and report to the Secretary of the Interior a just and equitable division of the fund to be received under this act between one college for white students and one institution for colored students established as aforesaid, which shall be divided into two parts and paid accordingly, and thereupon such institution for colored students shall be entitled to the benefits of this act and subject to its provisions, as much as it would have been if it had been included under the act of eighteen hundred and sixty-two, and the fulfillment of the foregoing provisions shall be taken as a compliance with the provision in reference to separate colleges for white and colored students.

SEC. 2. That the sums hereby appropriated to the States and Territories for the further endowment and support of colleges shall be annually paid on or before the thirty-first day of July of each year, by the Secretary of the Treasury, upon the warrant of the Secretary of the Interior, out of the Treasury of the United States, to the State or Territorial treasurer, or to such officer as shall be designated by the laws of such State or Territory to receive the same, who shall, upon the order of the trustees of the college, or the institution for colored students, immediately pay over said sums to the treasurers of the respective colleges or other institutions entitled to receive the same, and such treasurers shall be required to report to the Secretary of Agriculture and to the Secretary of the Interior, on or before the first day of September of each year, a detailed statement of the amount so received and of its disbursement. The grants of moneys authorized by this act are made subject to the legislative assent of the several States and Territories to the purpose of said grants: *Provided*, That payments of such installments of the appropriation herein made as shall become due to any State before the adjournment of the regular session of legislature meeting next after the passage of this act shall be made upon the assent of the governor thereof, duly certified to the Secretary of the Treasury.

SEC. 3. That if any portion of the moneys received by the designated officer of the State or Territory for the further and more complete endowment, support, and maintenance of colleges, or of institutions for colored students, as provided in this act, shall, by any action or contingency, be diminished or lost, or be misapplied, it shall be replaced by the State or Territory to which it belongs, and until so replaced no subsequent appropriation shall be apportioned or paid to such State or Territory; and no portion of said moneys shall be applied, directly or indirectly, under any

pretense whatever, to the purchase, erection, preservation, or repair of any building or buildings. An annual report by the president of each of said colleges shall be made to the Secretary of Agriculture, as well as to the Secretary of the Interior, regarding the condition and progress of each college, including statistical information in relation to its receipts and expenditures, its library, the number of its students and professors, and also as to any improvements and experiments made under the direction of any experiment stations attached to said colleges, with their costs and results, and such other industrial and economical statistics as may be regarded as useful, one copy of which shall be transmitted by mail free to all other colleges further endowed under this act.

SEC. 4. That on or before the first day of July in each year, after the passage of this act, the Secretary of the Interior shall ascertain and certify to the Secretary of the Treasury as to each State and Territory whether it is entitled to receive its share of the annual appropriation for colleges, or of institutions for colored students, under this act, and the amount which thereupon each is entitled, respectively, to receive. If the Secretary of the Interior shall withhold a certificate from any State or Territory of its appropriation the facts and reasons therefor shall be reported to the President, and the amount involved shall be kept separate in the Treasury until the close of the next Congress, in order that the State or Territory may, if it should so desire, appeal to Congress from the determination of the Secretary of the Interior. If the next Congress shall not direct such sum to be paid it shall be covered into the Treasury. And the Secretary of the Interior is hereby charged with the proper administration of this law.

SEC. 5. That the Secretary of the Interior shall annually report to Congress the disbursements which have been made in all the States and Territories, and also whether the appropriation of any State or Territory has been withheld, and if so, the reasons therefor.

SEC. 6. Congress may at any time amend, suspend, or repeal any or all of the provisions of this act.

Approved, August 30, 1890.

REGULATIONS OF THE POST-OFFICE DEPARTMENT FOR THE FREE TRANSMISSION IN THE MAILS OF THE BULLETINS AND REPORTS OF AGRICULTURAL EXPERIMENT STATIONS UNDER THE ACT OF CONGRESS OF MARCH 2, 1887.

(1) Any claimant of the privilege must apply for authority to exercise it to the Postmaster-General, stating the date of the establishment of such station, its proper name or designation, its official organization and the names of its officers, the name of the university, college, school, or institution to which it is attached, if any, the legislation of the State or Territory providing for its establishment, and any other granting it the benefits of the provision made by Congress as aforesaid (accompanied by a copy of the act or acts), and whether any other such station in the same State or Territory is considered, or claims to be, also entitled to the privilege; and also the place of its location and the name of the post-office where the bulletins and reports will be mailed. The application must be signed by the officer in charge of the station.

(2) If such application be allowed after examination by the Department, the postmaster of the proper office will be instructed to admit such bulletins and reports to the mails in compliance with these regulations, and the officer in charge of the station will be notified thereof.

(3) Paragraph 3, section 419, Postal Laws and Regulations 1887, is hereby amended so as to read as follows:

"Only such bulletins or reports as shall have been issued after the station became entitled to the benefits of the act can be transmitted free, and such bulletins or reports may be inclosed in envelopes or wrappers, sealed or unsealed. On the exterior of every envelope, wrapper, or package must be written or printed the name of the station and place of its location, the designation of the inclosed bulletin or report and the word 'Free' over the signature or facsimile thereof of the officer in charge of the station, to be affixed by himself, or by some one duly deputed by him for that purpose. There may also be written or printed upon the envelope or wrapper a request that the postmaster at the office of delivery will notify the mailing station of the change of address of the addressee, or other reason for inability to deliver the same, and upon a bulk package a request to the postmaster to open and distribute the 'franked' matter therein, in accordance with the address thereon.

"Bulletins published by the U. S. Department of Agriculture and analogous to those of the station, and entitled to be mailed free under the penalty envelope of that Department, may also be adopted and mailed by the several stations, with their own publications, under the same regulations, and any bulletins or reports mailable free by any agricultural experiment station under these regulations may be so mailed by any other station having free mailing authority.

"If such station's annual reports be printed by State authority, and consist in part of matter relating to the land grant college to which such station is attached, then said report may be mailed free entire by the director of the station; provided, in his judgment, the whole consists of useful information of an agricultural character."

The Post-Office Department has recently ruled that "in sending out bulletins from an agricultural experiment station it is permissible to inclose postal cards to enable correspondents of the station to acknowledge the receipt of its publications and to request their continuous transmission."

(4) The bulletins may be mailed to the stations, newspapers, or persons to whom they are by the foregoing act authorized to be sent, and the annual reports to any address within the United States,

RULINGS OF THE TREASURY DEPARTMENT AS TO THE CONSTRUCTION
OF THE ACT OF CONGRESS OF MARCH 2, 1887, ESTABLISHING AGRI-
CULTURAL EXPERIMENT STATIONS.

From copies of letters addressed to the Secretary of the Treasury and others by the First Comptroller of the Treasury, relating to the construction of the act of Congress of March 2, 1887, and acts supplementary thereto, the following digest has been prepared for the use of the stations. The sections are those of the act, the dates those of the decisions by the Comptroller:

Section 3—January 30, 1888.

That the annual financial statement of the stations, with vouchers, should not be sent to the Treasury Department, but that a copy simply of the report that is made to the governor is to be sent to the Secretary of the Treasury.

Section 3—January 31, 1888.

First. That the Treasury Department will not require officers of experiment stations to do or perform anything not specifically required by said bill.

Second. That the Secretary of the Treasury is not required to take a bond of the officers of said stations for the money paid over under the provisions of said act.

Third. That no reports will be required from the stations directly to the Secretary of the Treasury; but the governor of the State must send to the Secretary of the Treasury a copy of the report made to him by the colleges or stations.

Section 5—March 4, 1887.

“Congress only intended by the expression ‘the sum of fifteen thousand dollars is hereby appropriated to each State,’ to fix the amount that could be specially provided for by Congress in appropriations from year to year. Hence I conclude that section 5 does not make an appropriation; but that the same must be specially provided for by Congress.”

Sections 5 and 6—March 10, 1888.

(1) The appropriations are intended for the fiscal year and not the calendar year.

(2) The first annual report should be made on or before the 1st day of February, 1889, and said report should include simply the operations of the preceding fiscal year, not down to and including December 31, but up to and including June 30, 1888.

(3) The balance unexpended at the end of the fiscal year, the 30th of June preceding the report, must be accounted for in the report.

(4) The one-fifth proviso for building in section 5 can be made out of the first annual appropriation, to wit, that which commences on the 1st day of July, 1887, and terminates on the 30th of June, 1888.

(5) The intention of Congress was to make quarterly payments, not in advance, but at the end of each quarter.

Section 5, proviso—March 22, 1888.

"I have been informed that there is no farm connected with the agricultural college in Delaware. The act provides that one-fifth of the amount appropriated can be expended in the creation, enlargement, or repair of a building or buildings for carrying on the work of the station receiving the appropriation. I am in doubt whether, with this qualification, out of the balance of the appropriation a farm could either be purchased or rented. Another question in my mind is as to the competency of the legislature which was in session at the date of the passage of the act to accept, as it assumed to do, of the provisions of the act, the ninth section of which provides that 'Payment of such installments of the appropriation herein made as shall become due to any State before the adjournment of the regular session of its legislature meeting next after the passage of this act shall be made upon the assent of the governor thereof duly certified to the Secretary of the Treasury.'"

Section 6—April 24, 1888.

At the end of the present fiscal year, to wit, June 30, any portion of the \$15,000 which shall have been received, up to and including the payment made on the 1st day of July, which is unexpended, or which may not be necessary to pay claims under contracts made for the benefit of said agricultural station, must be deducted from the next annual appropriation, as specified in said sixth section.

Section 6—August 2, 1888.

The fiscal year commences on the 1st day of July, corresponding with the fiscal year of the Government.

An agricultural station entitled to the benefits of said appropriations made by Congress can anticipate the payment to be made July 1, and make contracts of purchases prior to that time, if it shall be necessary to carry on the work of the station. Of course no portion of said appropriations paid in quarterly installments can be drawn from the Treasury unless needed for the purposes indicated in the act; and so much of what is so drawn as may not have been expended within the year must be accounted for as part of the appropriation for the following year.

Section 8—January 30, 1888.

The State of New York ought to designate whether to the college or to the station, or to both, it desires the appropriation to be applied. The eighth section of the act seems to authorize the State to apply such benefits to experimental stations it may have established as it desires.

Where there are no experimental stations connected with the colleges, the legislatures of such States must connect the agricultural experiment stations with the colleges already established under the act of July 2, 1862; there is no authority in the act authorizing the establishment of agricultural experiment stations independent of said colleges.

The act contemplates that where stations have already been established disconnected from the colleges, the legislatures of such States may take such provisions in regard thereto as they may deem proper; but it does not authorize the establishment of stations except in connection with the colleges that were at that time or might thereafter be established under the act of July 2, 1862.

Section 8—February 14, 1888.

Where there is an agricultural college or station which may have been established by State authority, and is maintained by the State, the eighth section of the above act would authorize the State to designate the station to which it desired the appropriation to be applied, whether to one or more, or all, and the Secretary of the Treasury should make the payment under the appropriation to whichever one the State might designate.

Sections 1 and 8—February 15, 1888.

(1) When an agricultural college or station has been established under the act of July 2, 1862, each college is entitled to the benefits of the provisions of said act (i. e., of March 2, 1887).

(2) In a State where an agricultural college has been established under the act of July 2, 1862, and agricultural stations have also been established, either under the act of July 2, 1862, or by State authority, before March 2, 1887, the legislature of such State shall determine which one of said institutions, or how many of them, shall receive the benefits of the act of March 2, 1887.

(3) If the legislature of any State in which an agricultural college has been established under the act of July 2, 1862, desires to establish an agricultural station which shall be entitled to the benefits of said act it must establish such station in connection with said college.

Proviso to section 1 and section 8—December 7, 1888.

It is within the power of the legislature of any State that has accepted the provisions of said act of March 2, 1887, to dispose of the amount appropriated by Congress for said station to either one or all of the agricultural colleges or station which may have been established in said State by virtue of either the provisions of the act of July 2, 1862, or the provisions of said eighth section of the act of March 2, 1887.

The whole responsibility rests upon the State legislature as to how the fund appropriated by Congress shall be distributed among these various institutions of the State, provided there is one or more agricultural colleges with which an agricultural station is connected, or one or more agricultural stations.

Section 8—January 28, 1889.

The act of the State of Georgia in authorizing the governor to receive the fund to which the State may be entitled under the act of March 2, 1887, is not in conflict with any of the provisions of said act. If a State has established an agricultural college or station under the act of July 2, 1862, or if it has established an agricultural station in connection with said college, as provided in the eighth section of March 2, 1887, the legislature can authorize some person or persons to receive the money donated by the Government and direct its application in such way and manner as it seems best to carry out the objects and purposes of said acts of Congress to either the colleges or the station, or to both.

Section 9—February 4, 1888.

It appears by the statement of Representative Blount that there was a session of the legislature of the State of Georgia after the passage of the act and before the first payment became due, October 1, 1887, and which did not adjourn until after that time. That being the case, under the proviso of the section, the governor of the State can not assent to that payment which was to be made October 1, 1887. The legislature having adjourned before the second payment became due, without accepting the provisions of the bill, no further payment can be made to said State until the legislature thereof shall have accepted the provisions of the bill. You will observe, the language of the proviso, "that payments of the installments of the appropriation herein made as shall become due to any State before the adjournment of the regular session of its legislature" applies, certainly, only to such installments as become due before the final adjournment. The idea seems to be to give the legislature the full time before it adjourns to accept the provisions of the bill or not; but it is plain to my mind, that only such payments as become due before the adjournment of the legislature can be accepted by the governor of the State,

INDEX OF NAMES.

- Adams, C. G., 56.
Adams, C. K., 23, 53.
Adams, F. M., 33.
Adams, F. W., 44.
Adams, G. R., 10.
Adams, H. F., 24.
Adams, L. H., 28.
Aderhold, E. L., 42.
Adriance, D., 26, 54.
Adriance, J., 25.
Ailshie, J. F., 13.
Ainsworth, G. J., 10.
Alden, R., 16.
Alderson, B. C., 57.
Aldrich, C. R., 42.
Aldrich, J. M., 13.
Aldrich, W. S., 57.
Alford, T. G., 36.
Alger, J. L., 51.
Allen, E. A., 43.
Allen, H. N., 44.
Allen, W. M., 22.
Allison, J. W., 25.
Alvey, R. H., jr., 40.
Alvord, H. E., 59.
Alwood, W. B., 27, 56.
Amadon, A. M., 36.
Ames, C. T., 42.
Anderson, F. P., 38, 59.
Anderson, J., 43.
Anderson, J. T., 9, 29.
Anderson, J. W., 10.
Anderson, M. L., 34.
Anderson, S. C., 54.
Andrews, E. B., 51.
Andrus, J. F., 56.
Angell, S. M., 39.
Annis, F. J., 11.
Anthony, L. C., 43.
Antrim, E. I., 58.
Appell, J. F., 34.
Apperson, J. T., 23.
Appleton, F. H., 17.
Appleton, J. H., 51.
Armes, W. D., 31.
Armsby, H. P., 24, 50.
Armstrong, H. C., 9.
Armstrong, L. H., 56.
Armstrong, R. A., 57.
Arnold, C. L., 48.
Arnold, F. L., 17.
Arthur, J. C., 14, 33.
Arvy, L., 54.
Asbury, S. E., 47.
Ash, W. D., 30.
Atherton, G. W., 24, 50.
Atkinson, G. F., 22, 47.
Atkinson, T. W., 39.
Atwater, W. O., 11, 12.
Aubert, A. B., 40.
Ayer, A. W., 55.
Babcock, S. M., 28, 53.
Babcock, W., 41.
Babson, H., 41.
Bachelder, B., 56.
Bacon, A. M., 56.
Bailey, J. B., 18.
Bailey, L. H., 22, 47.
Bailey, Mark, 33.
Bailey, W. W., 51.
Bain, S. M., 25, 53.
Baker, A. E., 36.
Baker, C. F., 11, 32.
Baldwin, G., 24.
Baldwin, H. R., 21.
Balentine, W., 16, 40.
Banks, A. L., 54.
Banks, W. A., 14.
Barber, A. M., 35.
Barber, A. G., 26.
Barber, L. J., 33.
Barbour, E. H., 19, 44.
Barbour, E. L., 46.
Barbour, V. G., 55.
Barker, F. F., 46.
Barker, R. J., 23, 49.
Barnes, W. D., 21.
Barney, S. E., 33.
Barr, W. H., 42.
Barrow, D. C., jr., 35.
Barrow, D. N., 16, 39.
Barrows, A. C., 37.
Barrows, W. B., 41.
Barry, W. C., 21.
Bartlett, C., 10.
Bartlett, J. M., 16, 60.
Bartlett, W. P., 27.
Barton, C. M., 53.
Barton, J. M., 26.
Bascomb, F., 48.
Bashford, J. W., 27.
Bassel, J., 27.
Bates, H., 44.

- Bates, R. C., 52.
 Bates, W. F., 30.
 Bathews, H. B., 53.
 Battle, H. B., 22.
 Baxter, W., 38.
 Baya, H. P., 34.
 Beach, F., 11.
 Beach, F. E., 33.
 Beach, S. A., 21.
 Beal, W. J., 41.
 Beardshear, W. M., 14, 37.
 Beaver, L., jr., 46.
 Beckwith, M. H., 12, 33.
 Beem, D. E., 14.
 Beeson, J. L., 16.
 Belden, H. M., 44.
 Belknap, E. M., 49.
 Bell, M., 32.
 Bemiss, J. B., 43.
 Bender, F. B., 41.
 Bending, E. J., 34.
 Benuett, A. A., 37.
 Bennett, E. J., 58.
 Bennett, R. L., 10.
 Bennett, S. E., 15.
 Benson, M. A., 26.
 Bentley, W. B., 30.
 Benton, E. S., 39.
 Benton, H., 9.
 Berchtold, F., 49.
 Bessey, C. E., 19, 44.
 Betts, E., 46.
 Beyer, S. W., 37.
 Beyer, T. R., 50.
 Bielby, C. F. A., 12.
 Bigelow, F. M., 11.
 Bigelow, W. D., 60.
 Bioletti, F. T., 10.
 Bird, M., 16.
 Bishop, W. H., 12, 33.
 Bissell, G. W., 37.
 Bitting, A. W., 14, 36.
 Bittle, T. C., 54.
 Bivins, R. L., 9, 29.
 Black, B. C., 10.
 Black, J. M., 53.
 Black, R., 21.
 Blackburn, Mrs. L. B., 33.
 Blake, C. O., 23.
 Blake, E. W., 51.
 Blandford, H. S., 27.
 Blanton, R. L., 38.
 Blasdale, W. C., 31.
 Bledsoe, P., 54.
 Bleile, A. N., 48.
 Bloomfield, L. M., 48.
 Bloss, J. M., 23, 49.
 Blouin, R. E., 16.
 Blount, A. E., 21, 46.
 Boardman, A. I., 56.
 Boardman, C. D., 14.
 Boggs, E. M., 9, 30.
 Boggs, J., 10.
 Boggs, W. E., 13.
 Bohannon, R. D., 48.
 Boise, R. P., 23.
 Bolley, H. L., 22, 47.
 Bolton, E. B., 38.
 Bondurant, A. J., 9, 29.
 Bonebright, J. E., 13.
 Bontè, J. H. C., 10.
 Booker, W. M., 9.
 Bookstaver, H. W., 21.
 Boss, A., 18.
 Boss, W., 42.
 Bosworth, A., 51.
 Bottenfield, L. S., 47.
 Bowen, A. F., 22.
 Bowen, B. L., 48.
 Bowen, R. E., 24.
 Bowen, W. P., 44.
 Bowker, W. H., 17.
 Bowman, A., 35.
 Bowser, E. A., 46.
 Boyd, E., 37.
 Boyd, J. E., 48.
 Brace, D. B., 19, 44.
 Brackett, R. N., 25, 52.
 Bradford, J. N., 48.
 Bradley, C. B., 31.
 Bradley, J. E., 24.
 Bradley, R. C., 41.
 Brady, F. W., 36.
 Brady, W., 13, 14.
 Bray, R. T., 54.
 Breazeale, W. E., 46.
 Breese, C. M., 38.
 Brereton, J. J., 46.
 Brewer, F. W., 26, 55.
 Brewer, W. H., 11, 32.
 Brewster, F. A., 42.
 Brewster, H. W., 42.
 Briggs, B. F., 16.
 Briggs, F. C., 56.
 Briggs, F. P., 16, 40.
 Brigham, J. H., 23.
 Brill, T., jr., 22.
 Brink, C. M., 51.
 Brinkley, E. H., 17.
 Bristow, W. W., 49.
 Broadhead, G. C., 43.
 Broderick, W. H., 26.
 Brogles, M. H., 54.
 Bronson, W. C., 51.
 Brooke, St. G. T., 57.
 Brooks, W. P., 17, 41.
 Broughton, N. B., 22.
 Broun, W. L., 9, 29.
 Brown, A. B., 38.
 Brown, C. N., 48.
 Brown, F., 16.
 Brown, J. F., 27.
 Brown, J. N., 45.
 Brown, J. T., 26.
 Brown, N. G., 35.
 Brown, O., 56.
 Brown, R., 45.
 Brown, S. B., 57.
 Brown, W. W., 27.
 Browne, R. S., 13.
 Brownell, E. H., 51.
 Browning, W. D., 42.

- Bruce, C. M., 9.
 Bruner, L., 19, 44.
 Brush, G. J., 32.
 Bryan, E. A., 27, 57.
 Buckham, M. H., 26, 55.
 Buckhout, W. A., 24, 50.
 Budd, J. L., 14, 37.
 Buell, D. C., 15.
 Buffum, B. C., 28, 58.
 Bulkley, W. L., 52.
 Bull, M., 24.
 Bull, T. J., 21.
 Bullock, E. C., 58.
 Bullock, R. S., 15.
 Bumpus, H. C., 51.
 Bumstead, H. A., 33.
 Burgess, F. G., 31.
 Burnett, P. B., 44.
 Burnette, F. H., 16, 39.
 Burnham, E. C., 51.
 Burrill, T. J., 13, 14, 35.
 Burtis, F. C., 15.
 Burton, M. R., 29.
 Burton, W. W., 28.
 Burwell, L. E., 21.
 Burwell, R. T., 16.
 Butler, T., 18, 42.
 Butterfield, I. H., 18, 41.
 Butts, E. P., 50.
 Butz, G. C., 24, 50.

 Cady, W. B., 21.
 Caine, J. T., jr., 55.
 Calder, E. E., 51.
 Caldwell, F. C., 48.
 Caldwell, G. C., 22, 47.
 Caldwell, H. W., 44.
 Caldwell, W. H., 24, 50.
 Callahan, Mrs. Ida, 49.
 Cameron, A. G., 52.
 Cameron, J. R., 18.
 Campbell, G. F., 33.
 Campbell, Mrs. J. E., 58.
 Campbell, J. E., 58.
 Campbell, J. P., 35.
 Campbell, T. P., 56.
 Campbell, W. H., 23.
 Candy, A. L., 44.
 Canfield, J. H., 19, 44, 59.
 Canty, J. M., jr., 58.
 Capehart, W. R., 22.
 Card, F. W., 19, 44.
 Carleton, M. A., 15.
 Carnall, E. H., 30.
 Carpenter, F. B., 22.
 Carpenter, L. G., 11, 32.
 Carpenter, M. A., 17.
 Carroll, Mrs. S. C., 47.
 Carson, J. M., 26, 54.
 Carson, J. W., 26, 54.
 Carson, W. W., 53.
 Carter, J. G., 25.
 Carter, J. H., 54.
 Carter, H. L., 26.
 Cary, C. A., 9, 29.
 Cash, W. F., 13.

 Caudell, A. N., 23.
 Causey, W. F., 12.
 Cavanaugh, G. W., 22.
 Cavitt, W. R., 25.
 Caywood, V. H., 30.
 Chalmers, J., 48.
 Chamberlain, H., 17.
 Chamberlain, P. M., 41.
 Chambers, M. L., 37.
 Chambliss, C. E., 25.
 Chandler, R. E., 44.
 Chapin, C. V., 51.
 Chappell, W. L., 42.
 Charbonnier, L. H., 35.
 Chatfield, J. L., 11.
 Chaves, D., 21.
 Chesebro, C. H., 30.
 Chester, A. H., 46.
 Chester, E. E., 13.
 Chester, F. D., 12, 33.
 Chichester, F., 56.
 Chickering, J. K., 55.
 Chilcott, E. C., 25, 53.
 Chipley, W. D., 12.
 Chittenden, H. B., 55.
 Chittenden, R. H., 32.
 Church, J. E., jr., 45.
 Churchill, G. W., 21.
 Chynoweth, H. W., 27.
 Clapp, H. K., 20, 45.
 Clark, B. F., 51.
 Clark, E., 56.
 Clark, E. F., 49.
 Clark, E. G., 16.
 Clark, G., 18.
 Clark, H. A., 43.
 Clark, H. R., 49.
 Clark, J. E., 32.
 Clark, M. G., 56.
 Clark, O. E., 27.
 Clark, T. A., 35.
 Clark, W. G., 58.
 Clark, W. W., 37.
 Clarkson, J. S., 19.
 Clay, C. D., 38.
 Clayton, J., 26, 54.
 Cleaveland, L., 56.
 Clendenin, W. W., 16, 39.
 Cleveland, B., 56.
 Clinkscales, J. G., 52.
 Clinton, G. P., 14, 35.
 Clinton, L. A., 25, 52.
 Cloyd, D. M., 26.
 Clute, O., 12, 34.
 Coates, C. E., 39.
 Coates, J., 35.
 Coates, J. P., 16.
 Cockerell, T. D. A., 21, 40.
 Coe, J. W., 33.
 Coe, W. R., 33.
 Coffield, J. B., 22.
 Coffin, S. M., 13.
 Coggeshall, C. H., 24.
 Colburn, L. C., 58.
 Colby, D. W., 40.
 Colby, G. E., 10, 31.

- Colcock, D. D., 15.
 Colcord, R. K., 20.
 Cole, G. A., jr., 30.
 Cole, Mrs. G. A., 30.
 Coler, G. P., 48.
 Collier, P., 21.
 Collingwood, C. B., 9, 30.
 Collins, C. H., 25.
 Colvin, S. S., 51.
 Combs, F. J., 48.
 Comfort, J., 25.
 Comstock, J. H., 22, 47.
 Comstock, T. B., 9, 30.
 Condell, C., 56.
 Conklin, C., 44.
 Conley, J. D., 28, 58.
 Connell, J. H., 26, 54.
 Conner, C. R., 27.
 Connoway, J. W., 43.
 Conwell, C. S., 33.
 Conwell, S. L., 34.
 Cook, A. D., 21.
 Cooke, W. W., 11, 32.
 Cooley, F. S., 41.
 Cooper, J., 46.
 Cooper, W., 19.
 Coote, G., 23, 49.
 Corbett, L. C., 25, 53.
 Cormack, D. A., 25, 53.
 Corput, F., 13.
 Corse, F. M., 55.
 Corwin, R. N., 32.
 Coryell, R. J., 18.
 Coulter, S., 36.
 Covell, G. A., 49.
 Cowgill, T. W., 45.
 Craig, J. A., 28, 58.
 Craig, M., 23, 49.
 Craig, O. J., 36.
 Craighead, E. B., 25, 52.
 Crain, L. D., 32.
 Crampton, C. A., 60.
 Crandall, C. S., 11, 32.
 Crane, A. A., 13.
 Crane, A. B., 53.
 Cravens, J. L., 30.
 Crawford, J. D., 35.
 Creditt, W. A., 39.
 Creelman, G. C., 42.
 Crenshaw, B. H., 29.
 Crocker, C. F., 10.
 Crocker, C. S., 17.
 Crook, A. J., 13.
 Crosby, D. J., 41.
 Crowell, A. C., 51.
 Cunningham, W. N., 50.
 Cuppage, A., 34.
 Curtis, H. E., 15.
 Curtis, R. S., 11.
 Curtiss, C. F., 14, 37.
 Cushman, S., 24, 51.
 Dabney, C. W., jr., 25, 53.
 Dale, H. B., 27.
 Dales, J. S., 19.
 Daly, B., 23.
 Daniels, A. L., 55.
 Dausette, C. W., 29.
 Daule, E. A., 54.
 Davenport, T. W., 23.
 Davidson, J. N., 14.
 Davidson, R. J., 27, 56.
 Davis, C. A., 33.
 Davis, C. K., 18.
 Davis, E. B., 45.
 Davis, E. W., 44.
 Davis, G. C., 18, 41.
 Davis, J. E., 56.
 Davis, J. M., 38.
 Davis, M., 30.
 Davis, M. A., 39.
 Davis, N. F., 51.
 Davis, W. L., 15.
 Davisson, A. E., 40.
 Dealey, J. Q., 51.
 Decker, J. W., 28, 58.
 DeFoe, L. M., 43.
 Delabarre, E. B., 51.
 Demarest, S. R., jr., 20.
 Demond, J. H., 17.
 Denise, D. D., 20.
 Dennis, L. M., 47.
 Denny, J. V., 48.
 DePass, W. G., 12.
 Derby, S. C., 48.
 DeRoode, R. J. J., 27.
 Deschenes, J., 22.
 DeSha, B. C., 34.
 Detmers, H. J., 48.
 Dickerson, W. M., 41.
 Dilley, B. M., 19.
 Dinwiddie, R. R., 10.
 Doane, W. E., 58.
 Dockery, T. C., 18.
 Dodge, D. K., 35.
 Donahue, M. F., 26.
 Donaldson, M. L., 24.
 Donaldson, T. Q., jr., 52.
 Doolittle, M., 37.
 Doty, G. W., 20.
 Dow, F. T., 57.
 Dowdy, R. W., 30.
 Downey, S. W., 28.
 Downing, S. R., 24.
 Drake, W. E., 51.
 Draper, J., 17.
 Dresser, J. M., 14.
 Drew, E. R., 31.
 Drew, J. M., 42.
 Drinkhard, A. W., 56.
 Droke, G. W., 30.
 Dryden, J., 26, 55.
 DuBois, A. J., 32.
 DuBois, J. E., 11.
 Duff, A. W., 36.
 Dunbar, C. M., 14.
 Duncan, E. E., 39.
 Dunkel, H. E., 50.
 Dunn, J. B., 47.
 Dunn, T. A., 28.
 Dunstan, A. St. C., 29.
 Danton, L. M., 52.

Dunton, Mrs. L. M., 52.
 DuPre, J. F. C., 25.
 Durkee, O. P., 51.
 Duryee, A. W., 20.
 Duryee, W. R., 46.
 Dutcher, J. B., 22.
 Dwight, T., 32.
 Dye, C. A., 48.

Earle, F. S., 18.
 Earle, J. J., 34.
 Easterbrook, H. D., 19.
 Eaton, D. C., 32.
 Eddy, Mrs. S. A., 55.
 Edgerton, E. A., 41.
 Edgren, A. H., 44.
 Edwards, G. C., 31.
 Edwards, H., 41.
 Ege, R., 20.
 Eggers, E. A., 48.
 Eldon, W. S., 48.
 Ellis, A., 11, 32.
 Ellis, S. H., 23.
 Ellsworth, E. A., 14.
 Emery, F. E., 22, 47.
 Emery, F. P., 50.
 Emery, Mrs. M. W., 45.
 Emery, S. M., 19, 44.
 Emigh, A. L., 11.
 Emmett, J., 23.
 Engle, T. P., 40.
 Erwin, R. W., 26.
 Estabrooke, H. M., 40.
 Evans, Mrs. P. A., 47.
 Everett, W. G., 51.
 Eves, H. P., 33.
 Ewing, A. A., 23.

Failyer, G. H., 15, 38.
 Fairchild, G. T., 15, 38, 59.
 Falkenbach, F. J., 23.
 Farewell, S. T., 28.
 Farnam, H. W., 32.
 Farnsworth, T. J., 27.
 Farrington, E. H., 13, 14, 60.
 Fassett, G. S., 26.
 Ferguson, H. C., 43.
 Ferguson, J., 57.
 Ferguson, R. J., 9.
 Fernald, C. H., 17, 41.
 Fernald, H. C., 40.
 Fernald, H. T., 50.
 Fernald, M. C., 16.
 Ferris, C., 53.
 Field, G. W., 51.
 Fields, J. D., 25.
 Fields, J. W., 24.
 Finley, C. A., 12.
 Finley, G. J., 18.
 Fish, H. L., 20.
 Fitts, E. B., 12.
 Fitzgerald, T. S., 26.
 Flagg, C. O., 24, 51.
 Flather, J. J., 36.
 Fleming, A. M., 26.
 Fletcher, J. C., 23.

Fling, F. M., 44.
 Flint, E. R., 41.
 Flint, W., 40.
 Flower, R. P., 21.
 Folsom, N. E., 53.
 Foote, H. S., 10.
 Forbes, S. A., 13, 14, 35.
 Ford, C., 37.
 Ford, R., 9.
 Forrer, J., 10.
 Forsyth, A. P., 15.
 Forsyth, J., 20.
 Fortier, S., 26, 55.
 Foss, F. E., 50.
 Fossler, L., 44.
 Foster, I. L., 51.
 Foster, L., 19, 44.
 Foster, M. J., 15.
 Fowler, J. M., 14.
 Fox, A. F., 18.
 Fox, C. P., 13.
 Francis, M., 26, 54.
 Franklin, S. M., 9.
 Franklin, W. S., 37.
 Fratt, N. D., 27.
 Frear, W., 24, 50, 59, 60.
 Frederick, H., 20.
 Frelinghuysen, F., 21.
 Freeman, D., 56.
 Freeman, M. P., 9.
 French, A. R., 24.
 French, H. T., 23, 49.
 French, W. A., 27.
 Friend, T. C., 58.
 Frier, J. H., 33.
 Fries, H. E., 22.
 Fries, J. A., 24.
 Frissell, H. B., 56.
 Frith, W. O., 56.
 Frost, A. S., 53.
 Frothingham, L., 32.
 Frye, R. T., 13.
 Fuller, F. D., 20.
 Fulmer, E., 27, 57.
 Fulton, J. A., 12.
 Fulton, J. F., 23, 49.
 Furman, C. M., 52.
 Furnas, R. W., 44.

Gallaway, W. H., 42.
 Gallegos, J., 11.
 Gardner, F. D., 14, 35.
 Gardner, H. B., 51.
 Gardner, J., 27, 56.
 Garig, W., 15.
 Garfield, C. W., 17.
 Garman, H., 15, 38.
 Garside, J. A., 30.
 Garver, M. M., 50.
 Gault, F. B., 13, 35.
 Gaut, J. W., 25.
 Gayley, C. M., 31.
 George, J. Z., 18.
 Georgeson, C. C., 15, 38.
 Gerrish, C., 36.
 Gibbs, L. R., 46.

- Gibbs, T. V., 34.
 Gibbs, W. D., 35.
 Gibson, H., 15.
 Giese, J., 25.
 Giesecke, F. E., 54.
 Gilchrist, J. G., 9.
 Gill, B., 50.
 Gillespie, A. C., 54.
 Gillette, C. P., 11, 32.
 Gilman, C. L., 31.
 Gilmer, J. H., 22.
 Gird, R., 11.
 Gladden, H. P., 18.
 Gleason, C. A., 17.
 Glidden, A. C., 17.
 Glover, M., 52.
 Goessman, C. A., 17, 41.
 Goessman, L. E., 17.
 Goff, E. S., 28, 58, 59.
 Gorham, F. P., 51.
 Gold, T. S., 11, 12.
 Golden, K. E., 36.
 Golden, M. J., 36.
 Goldsborough, W. E., 30.
 Goodale, W. H., 39.
 Goodall, W. H., 32.
 Goodell, H. H., 17, 41, 59.
 Goodenough, G. A., 41.
 Goodrich, C. L., 56.
 Gorton, L. G., 17, 18, 41.
 Goss, A., 21, 46.
 Goss, W. F. M., 36.
 Gould, F. H., 10.
 Gould, H. P., 16.
 Gowell, G. M., 40.
 Graham, E. J., 42.
 Graham, I. D., 15, 38.
 Grange, E. A. A., 18, 41.
 Granville, W. A., 33.
 Gray, J. C., 24.
 Gray, O. C., 30.
 Green, A. L., 36.
 Green, C. J., 24.
 Green, E. C., 23.
 Green, L. E., 39.
 Green, S. B., 18, 42.
 Green, W. F., 23.
 Green, W. H., 20.
 Green, W. J., 33.
 Greene, E. L., 10, 31.
 Greene, J. F., 51.
 Greenhalge, E. B., 17.
 Gregory, J. M., 35.
 Griffin, H. H., 21.
 Grishart, J. H., 40.
 Groesbeck, W. D., 41.
 Grover, N. C., 40.
 Guild, F. T., 51.
 Gulley, A. G., 26, 55.
 Gulley, F. A., 9, 30.
 Gunson, T., 41.
 Gwinner, H., 42.
 Gwynn, W., 12.
 Hadley, E. A., 19.
 Hadley, H., 21, 46, 59.
 Haecker, A. L., 42.
 Haecker, J. H., 42.
 Haecker, T. L., 18, 42.
 Hagan, A. B., 12.
 Hageman, E. H., 58.
 Hagerty, C. T., 46.
 Halbrook, J. M., 49.
 Hale, F. G., 25.
 Hale, J. H., 12.
 Haley, E. J., 24.
 Hall, H. J., 30.
 Hallidie, A. S., 10.
 Halsted, B. D., 21, 46.
 Hamlin, G. H., 40.
 Hamlin, J. T., 26.
 Hammond, M. R., 56.
 Hammond, S. H., 21.
 Hampsen, W. B., 44.
 Hansen, N. E., 14, 37.
 Hanson, G., 11.
 Hardin, J. H., 24.
 Hardin, M. B., 25, 52.
 Hare, A. J., 57.
 Hare, C. L., 9, 29.
 Hare, R. F., 21, 46.
 Harkins, L. A., 53.
 Harkness, A., 51.
 Harkness, A. G., 51.
 Harman, J. A., 56.
 Harper, J., 38.
 Harrington, H. H., 26, 54.
 Harris, A. W., 16, 40, 59.
 Harris, F. E., 12.
 Harris, R. L., 43.
 Harrison, H. E., 18.
 Harrison, H. S., 40.
 Harrison, T. P., 52.
 Harrold, E., 38.
 Hart, C. E., 46.
 Hart, J. N., 40.
 Hart, J. W., 25, 52.
 Harter, G. A., 33.
 Hartigan, J. W., 57.
 Hartsell, J. C., jr., 52.
 Hartshorn, C. L., 17.
 Hartwell, B. L., 24, 51.
 Harvey, F. L., 16, 40.
 Harvey, J. I., 27, 57.
 Haskell, M. W., 31.
 Haskins, H. D., 17.
 Hastings, C. S., 32.
 Hatch, J. M., 41.
 Hathaway, C. A., 39.
 Hathaway, J. S., 39.
 Hatt, W. K., 36.
 Hattabaugh, I. C., 13.
 Hayden, W. G., 22, 47.
 Hayes, M., 12.
 Hayne, A. P., 10, 31.
 Haynes, J. W., 20.
 Hays, W. M., 18, 42.
 Hawkins, R. D., 36.
 Hawkins, T. S., 15.
 Headden, W. P., 11, 32.
 Heatwole, J. P., 18.
 Hebard, G. R., 28.
 Heberly, J. A., 9.

- Hedrick, W. O., 41.
 Hellman, I. W., 10.
 Helme, M. P., 51.
 Helveti, F. M., 38.
 Henderson, J. T., 10.
 Henderson, L. F., 13.
 Henderson, R., 47.
 Henneman, J. B., 53.
 Henry, W. A., 28, 58, 59.
 Herbert, J. C., 42.
 Herget, A. M., 42.
 Herr, J. A., 24.
 Herrman, von, C. F., 22.
 Herron, E., 56.
 Herron, L. E., 56.
 Hersey, M. L., 40.
 Herty, C. H., 35.
 Heugstler, L. T., 31.
 Hewit, E. F., 25, 53.
 Heywood, A. R., 26.
 Heywood, J. S., 52.
 Hiatte, W. G., 22, 47.
 Hickman, J. F., 23.
 Hicks, F. C., 43.
 Higgins, J. C., 12.
 Hileland, L. D., 34.
 Hilgard, E. W., 10, 31, 60.
 Hill, D. H., jr., 47.
 Hill, H. A., 39.
 Hill, J. H., 58.
 Hillman, F. H., 20, 45.
 Hills, E. R., 35.
 Hills, J. L., 26, 55.
 Hine, J. S., 23.
 Hinebauch, T. D., 22, 47.
 Hitchcock, A. S., 15, 38.
 Hitchcock, E. A., 48.
 Hitchcock, H. E., 44.
 Hoak, B. M., 36.
 Hodgman, T. M., 44.
 Hofer, T. R., 20.
 Hoff, H. H., 13.
 Hoffman, B. F., 39.
 Hoffman, J. D., 36.
 Holdsworth, W. S., 41.
 Holladay, A. Q., 47.
 Holland, E. B., 17.
 Hollingsworth, J. E., 25.
 Hollis, A. P., 43.
 Holmes, E. H., 54.
 Holmes, S. J., 31.
 Holswade, J. M., 27.
 Holt, J. H., 29.
 Holter, G. L., 23, 49.
 Homer, R. H., 28.
 Hood, O. P., 38.
 Hook, J. N., 25.
 Hopkins, A. D., 27.
 Hopkins, C. G., 25, 53.
 Hopkins, T. C., 50.
 Horner, D. W., 20.
 Horner, J. B., 49.
 Hoskins, G. W., 50.
 Hossinger, J., 12.
 Hough, C., 57.
 Houghton, J. F., 10.
 House, W. L., 38.
 Howard, A., 57.
 Howard, A. J., 43.
 Howard, B. B., 51.
 Howard, C. S. H., 31.
 Howe, A., 56.
 Howe, D. D., 26.
 Howe, E. D., 17.
 Howe, H. M., 18.
 Howe, M. A., 31.
 Howe, W. T. H., 33.
 Howell, J. F., 30.
 Howes, G. E., 56.
 Hoyt, E., 11.
 Hubbard, J. M., 12.
 Huff, L. J., 55.
 Huffington, M. J., 11, 32.
 Huggins, J., 9.
 Humphrey, H. D., 32.
 Hunnicutt, J. B., 35.
 Hunt, T. F., 48.
 Huntington, S. D., 31.
 Huntley, F. A., 11.
 Hurt, W. W., 56.
 Hussey, G. B., 44.
 Huston, H. A., 14, 36, 60.
 Hutchinson, E. W., 54.
 Hutchinson, T. P., 16.
 Hutchinson, W. L., 18, 42.
 Hutson, C. W., 54.
 Hutto, W. W., 49.
 Hyde, E., 56.
 Hyde, E. H., 11, 12.
 Hyde, J. E., 26.
 Ihlseng, M. C., 50.
 Ingersoll, C. A., 33.
 Ingersoll, C. L., 19, 44.
 Ingraham, E. S., 27.
 Irby, B., 47.
 Irby, G. B., 10.
 Ives, C. E., 39.
 Ives, G. R., 14, 36.
 Ives, M. V. B., 21.
 Jackson, I. J., 39.
 Jackson, J. H., 39.
 Jackson, J. P., 50.
 Jackson, R. D., 45.
 Jackson, W. H., 25.
 Jaffa, M. E., 10, 31.
 James, W. D., 25.
 Jameson, J. B., 27.
 Jameson, J. F., 51.
 Jamieson, H., 39.
 Jarnagin, M. P., 25.
 Jenkins, E. H., 11.
 Jenks, J. P. W., 51.
 Jenter, C. G., 21.
 Jepson, W. L., 31.
 Jesse, R. H., 19, 43.
 Josup, H. G., 45.
 Johns, J. D., 54.
 Johnson, A. A., 28, 53.
 Johnson, A. B., 51.
 Johnson, C. H., 17.

Johnson, D. D., 27, 36.
 Johnson, G. B., 43.
 Johnson, J. R., 38.
 Johnson, M., 53.
 Johnson, S., 14.
 Johnson, S. W., 11, 12, 32, 59.
 Johnston, E., 56.
 Johnston, J., 27.
 Johnston, J. L., 57.
 Johnston, M. R., 28.
 Johnston, W. R., 11.
 Johnstone, A., 24.
 Jones, A. W., 28.
 Jones, C., 21.
 Jones, C. H., 17.
 Jones, C. L., 20.
 Jones, E. A., 21.
 Jones, F. F., 34.
 Jones, H. M., 38.
 Jones, J. S., 14.
 Jones, L. R., 26, 55.
 Jones, O. B., 48.
 Jones, S. A., 20, 45.
 Jones, S. C., 16.
 Jones, W., 36.
 Jordan, A. T., 15.
 Jordan, T. W., 53.
 Jordan, W. H., 16.
 Jouett, J. R., 51.

Kahn, H., 21.
 Kaley, C. W., 19.
 Karns, T. C., 53.
 Kastle, J. H., 38.
 Kauffman, G. B., 43.
 Kaufman, E. E., 47.
 Keady, W. P., 23.
 Kedzie, F. S., 41.
 Kedzie, Mrs. N. S., 33.
 Kedzie, R. C., 18, 41.
 Keeler, J. B., 26.
 Keene, E. S., 47.
 Keffer, C. A., 19, 43.
 Keith, C., 27.
 Kellerman, W. A., 43.
 Kelley, H., 15.
 Kellicott, D. S., 48.
 Kellner, E., 10.
 Kellogg, A. L., 11.
 Kellogg, M., 10, 31.
 Kemmler, E. A., 48.
 Kendall, A., 28.
 Kennedy, A. B., 39.
 Kennedy, T. L., 29.
 Kent, D. A., 14, 37.
 Kenyon, C., 55.
 Kerr, C. V., 30.
 Kester, M. J., 27.
 Keys, H., 20.
 Kidd, R. M., 56.
 Kilgore, B. W., 22, 60.
 Kimbro, H. F., 54.
 Kimbrough, J. M., 13.
 King, C. I., 58.
 King, F. H., 28, 58.
 King, M. S., 43.

King, R. C., 18, 42.
 Kingsbury, A., 45.
 Kinkaid, T. W., 50.
 Kinkead, W. B., 15.
 Kinkel, G., jr., 19.
 Kinley, D., 35.
 Kinney, L. F., 24, 51.
 Kirkland, A. H., 17.
 Kiruckenberg, H. J., 11.
 Klimpe, P., 33.
 Knapp, H., 14.
 Knight, G. W., 48.
 Knight, J. L. H., 19.
 Knight, W. A., 48.
 Knight, W. C., 28.
 Knisely, A. L., 21.
 Knott, J. E., 58.
 Knowlton, D. H., 16.
 Koch, J. J., 30.
 Koch, P., 19.
 Kolb, J. E., 36.
 Koons, B. F., 12, 33.
 Kower, H., 31.
 Kyle, H. G., 25.

Ladd, E. F., 22, 47.
 Lake, E. R., 27, 57.
 Lamson, H. H., 20, 45.
 Landon, Mrs. L. E., 18, 41.
 Lane, F. A., 51.
 Lane, H. D., 9.
 Lane, J. H., 29.
 Lang, A. F., 31.
 Lang, H., 11.
 Langdon, C., 51.
 Langford, W. H., 10.
 Lantz, D. E., 38.
 Larson, L. K., 25.
 Latta, W. C., 14, 36.
 Law, J., 22, 47.
 Lawrence, J. W., 32.
 Lawson, A. C., 31.
 Lazenby, W. R., 48.
 LeConte, J., 31.
 Lee, J. G., 16.
 Lee, S. D., 18, 42, 59.
 Lehman, A., 16.
 Leighton, F. A., 37.
 Lenher, V., 31.
 Lennox, T., 37.
 Lester, F. E., 21.
 Letcher, J. D., 49.
 Leuschner, A. O., 31.
 Leverett, C. H., 30.
 Lewers, R., 45.
 Lewis, A., 55.
 Lewis, C. A., 54.
 Lewis, E. A., 41.
 Lewis, J. F., 28.
 Lieckie, C. W., 54.
 Liggett, W. M., 18.
 Ligon, R. F., 9.
 Lincoln, J. R., 37.
 Lindsey, J. B., 17.
 Linfield, F. B., 55.
 Lipscomb, D., 42.

Lipscomb, M. L., 43.
 Little, B. B., 38.
 Little, E. A., 55.
 Livingston, H. T., 53.
 Lloyd, E. R., 18.
 Lloyd, R., 44.
 Lockwood, E. H., 32.
 Lodeman, E. G., 22, 47.
 Loehner, W., 46.
 Logan, J. L., 38.
 Logan, W., 43.
 Logie, T., 46.
 Loomis, H., 55.
 Lord, H. C., 48.
 Lord, N. W., 48.
 Loucks, J. D., 28.
 Loughridge, R. H., 10, 31.
 Lounsberry, C. P., 17.
 Lounsberry, R. A., 20.
 Lounsberry, T. R., 32.
 Love, J. L., 43.
 Lowe, F. F., 56.
 Lowe, W. I., 32.
 Lowell, A. G., 45.
 Lowell, J., 22.
 Luchsinger, J., 42.
 Ludlow, G. C., 21.
 Ludlow, H. W., 56.
 Lugger, O., 18, 42.
 Luke, F. K., 25.
 Lyman, R. W., 41.
 Lytle, A., 36.

McArdle, H. W., 47.
 McBride, G. W., 23.
 McBryde, J. B., 25.
 McBryde, J. M., 27, 56.
 McCarthy, G., 22.
 McCarthy, J., 20.
 McClaskey, E. W., 50.
 McClellan, J. H., 11.
 McClellan, J. S., 11.
 McCluer, G. W., 14.
 McCoard, G. W., 48.
 McColl, J. R., 53.
 McCormack, D. A., 53.
 McCormick, J. F., 18.
 McCornick, W. S., 26.
 McCurdy, C. W., 13, 35.
 McDonald, C. M., 58.
 McDonnell, M. E., 24.
 McDonnell, H. B., 40.
 McDowell, A. V., 23.
 McDowell, R. H., 20, 45.
 McElroy, E. B., 23.
 McElroy, W. O., 14.
 McElwain, H. A., 50.
 MacEwan, E. J., 55.
 McFie, J. R., 21.
 McGee, W. E., 31.
 McGee, W. L., 25, 52.
 MacGillivray, A. D., 47.
 McHugh, J. K., 16.
 MacIntosh, D., 14, 35.
 McKay, A. B., 18, 42.

Mack, C. E., 20.
 McKeen, B. W., 16.
 McKenna, P., 22.
 McKinley, W., jr., 23.
 McKissick, A. F., 29.
 McLelland, J. R., 22.
 McLouth, L., 25, 53.
 McNeill, J. F., 30.
 McNutt, J. W., 26.
 McPherson, J. H. T., 35.
 McPherson, W., jr., 48.
 McRae, Mrs. E. M., 36.
 Magee, W. A., 43.
 Magruder, A. C., 23, 49.
 Magruder, W. H., 42.
 Mahoney, S., 18.
 Maiden, B. F., 44.
 Manatt, J. I., 51.
 Manley, J. M., 51.
 Manning, H. P., 51.
 Marcheselli, J. B., 30.
 Markham, H. H., 10.
 Marks, C. W., 43.
 Marks, N. B., 29.
 Marlatt, A. L., 55.
 Marlatt, F. A., 15.
 Marrs, S. E., 10.
 Marston, A., 37.
 Martinet, L. M., 39.
 Martin, A., 43.
 Martin, J. C., 34.
 Martin, J. W., 10.
 Martin, M., 30.
 Marye, G. T., jr., 10.
 Mason, S. C., 15, 38.
 Massey, J. E., 26.
 Massey, R., 43.
 Massey, W. F., 22, 47.
 Mather, J. W., 33.
 Mathews, C. W., 15, 38.
 Matthews, H. B., 25.
 Maxwell, A. M., 42.
 Maxwell, W., 16.
 Mayers, S. V., 27.
 Maynard, S. T., 17, 41.
 Mayo, N. S., 15, 38.
 Mayo, J. W., 55.
 Meacham, J. T., 47.
 Mead, C. D., 52.
 Mead, Mrs. C. D., 52.
 Meek, Mrs. S. E., 30.
 Meek, S. E., 30.
 Meeker, W. H., 37.
 Mell, P. H., 9, 29.
 Mellen, G. F., 53.
 Mendel, L. B., 32.
 Menke, A. E., 30.
 Mercier, W. B., 16.
 Merriam, O. C., 18.
 Merrick, W., 28.
 Merrill, G. P., 51.
 Merrill, K., 35.
 Merrill, L. H., 16.
 Merrill, N. F., 55.
 Meske, A., 21.
 Mesloh, C. W., 48.

Metcalf, M., 56.
 Meyer, C., 46.
 Meyer, J. S., 28.
 Meyers, W. J., 32.
 Miles, H. C., 12.
 Miliken, B., 13.
 Miller, A., 10.
 Miller, C., 26.
 Miller, C. Van M., 35.
 Miller, H. F., 22.
 Miller, H. K., 29.
 Miller, R. H., 17.
 Miller, W. McN., 45.
 Miller, T. C., 57.
 Milligan, D., 13.
 Milliken, R., 35.
 Mills, A. A., 26, 55.
 Mills, G. F., 17, 21, 41.
 Mills, J. W., 11.
 Mitchell, G. A., 46.
 Mixter, W. G., 32.
 Mobley, J. H., 13.
 Moncreiff, W. F., 52.
 Montgomery, J. F., 42.
 Montgomery, W. B., 18.
 Mooers, C. A., 25.
 Moore, A. L., 16.
 Moore, C., 56.
 Moore, C. F., 17.
 Moore, J. F., 10.
 Moore, J. M., 30.
 Moore, R. S., 36.
 Moreland, J., 27.
 Morgan, H. A., 16, 39.
 Morgan, W. H., 18.
 Morris, J., 35.
 Morrill, C. H., 19.
 Morrey, C. B., 48.
 Morris, L. B., 11, 12.
 Morrison, N. B., 13.
 Morrison, W. S., 52.
 Morrow, G. E., 13, 14, 35, 59.
 Morse, A. B., 37.
 Morse, B. C., 54.
 Morse, F. W., 20, 45.
 Moses, B., 31.
 Moss, M., 9.
 Mount, W. D., 51.
 Mumford, F. B., 18, 41.
 Muncy, V. E., 38.
 Munro, C. C., 39.
 Munro, W. H., 51.
 Munson, W. M., 16, 40.
 Murfee, E. H., 10, 30.
 Murkland, C. S., 20, 45.
 Murphy, D. J., 12.
 Murphy, W. H., 53.
 Murray, B. L., 21.
 Murray, J., 38.
 Myers, G. W., 35.
 Myers, J. A., 27.
 Myers, W. S., 46.
 Myln, A. H., 24.

 Nagle, J. C., 54.
 Nash, W., 23.

Neal, J. C., 23, 49.
 Neale, A. T., 12.
 Neall, J. M., 45.
 Needham, D., 17.
 Neff, E. H., 36.
 Neilson, J., 20, 21.
 Nelson, A., 28, 58.
 Nelson, J., 21, 46.
 Nelson, J. P., 38.
 Nelson, K., 18.
 Nesbitt, R. T., 13.
 Ness, H., 54.
 Netherton, F. J., 9.
 Nettleton, M. W., 56.
 Neville, J. H., 38.
 Newhall, B., 51.
 Newman, C. L., 10.
 Newman, J. S., 59.
 Newman, J. W., 38.
 Newsom, H. C., 15.
 Newton, F. E., 21.
 Nicholas, P. N., 21.
 Nichols, E. R., 38.
 Nicholson, H. H., 19, 44.
 Nicholson, J. W., 16, 39.
 Nickerson, W. J., 39.
 Niemyer, J. H., 33.
 Niles, E. P., 27, 56.
 Niles, W. B., 14, 37.
 Niswander, F. J., 28, 53.
 Noble, A. B., 41.
 Noble, R. E., 9, 29.
 Nordstrum, H., 37.
 Norris, D. K., 24.
 Norris, R. S., 31.
 Northrop, C., 18, 42.
 Norton, S. A., 48.
 Nourse, D. O., 27, 56.
 Norwood, J., 13.
 Noyes, G. H., 27.
 Noyes, H. J., 58.
 Nunn, R., 22.

 Off, E. C., 36.
 Ogden, A. W., 11.
 O'Hanlon, W., 21.
 Olcott, J. B., 11.
 Olding, E. E., 16.
 Olin, O. E., 38.
 Olney, L. D., 21.
 O'Neill, E., 31.
 Onley, D. W., 34.
 Ormsbee, E. J., 26.
 Orr, J. L., 24.
 Orton, E., 48.
 Osborn, H., 14, 37, 59.
 Osborne, T. B., 11.
 Osmond, I. T., 50.
 Ostrander, J. E., 13, 35.
 Otis, D. H., 15.
 Ott, H. N., 25, 53.
 Ousley, B. F., 43.
 Owen, S. M., 18.
 Owens, Mrs. E., 37.
 Owen, J. P., 46.
 Owens, J. R., 17, 40.

- Owens, R. B., 44.
- Packard, A. S., 51.
- Paddock, W., 21.
- Page, I. E., 43.
- Paget, F. V., 31.
- Paige, J. B., 41.
- Palmer, A. D., jr., 51.
- Palmer, A. W., 35.
- Pammel, L. H., 14, 37, 53.
- Pardee, W. J., 51.
- Park, C. B., 47.
- Park, J. B., jr., 13.
- Parker, C., 44.
- Parker, F. E., 51.
- Parker, G. W., 35.
- Parker, J. D., 28.
- Parkinson, J. B., 34.
- Parkinson, J. M., 25, 53.
- Parr, S. W., 35.
- Parrott, J. R., 56.
- Parsons, C. L., 20, 45.
- Patrick, G. E., 14, 37.
- Patterson, H. J., 17, 60.
- Patterson, J. K., 15, 38.
- Patterson, L. G., 18.
- Patterson, W. C., 21.
- Patterson, W. K., 38.
- Patton, G. E., 32.
- Paulson, P. M., 42.
- Payne, F., 26.
- Payne, F. H., 31.
- Payne, J. F., 22.
- Payne, L. W., jr., 29.
- Payson, E. R., 46.
- Peabody, G. F., 56.
- Peck, C., 26.
- Peck, T. F., 25.
- Peebles, A. B., 33.
- Peets, G. H., 18.
- Pemberton, J., 50.
- Pence, M. L., 38.
- Pendergast, W. W., 18.
- Penfield, S. L., 33.
- Penfield, T. J., 52.
- Pennoyer, S., 23.
- Penny, C. L., 12, 33.
- Perin, S. W., 19.
- Perkins, C. A., 53.
- Perkins, G. H., 26, 55.
- Perkins, W. R., 42.
- Pernot, E., 49.
- Pershing, J. J., 44.
- Persons, A. A., 12, 34.
- Peter, A. M., 15, 60.
- Peter, R., 38.
- Peters, A. T., 19.
- Peterson, C. D., 36.
- Petrie, G., 29.
- Pettee, C. H., 20, 45.
- Pettit, J. S., 33.
- Phelps, C. S., 12, 33.
- Phelps, E., 17.
- Phelps, H. G., 19, 44.
- Phelps, T. G., 10.
- Phillips, A. E., 36.
- Phillips, J. W., 45.
- Phillips, W. H. H., 53.
- Philpott, W. B., 54.
- Pierce, A. B., 31.
- Pierce, J. R., 38.
- Pierce, N. D., 24.
- Pierson, F. E., 56.
- Pillsbury, A. J., 10.
- Pillsbury, J. S., 18.
- Pillsbury, W. L., 14.
- Pinney, E. C., 12.
- Piper, C. V., 27, 57.
- Pirsson, L. B., 33.
- Plumb, C. S., 14, 36.
- Plummer, D. L., 27.
- Poland, W. C., 51.
- Pond, F. J., 50.
- Pond, G. G., 50.
- Pond, M. A., 33.
- Pond, P. F., 56.
- Popenoe, E. A., 15, 33.
- Porter, E. D., 19, 43.
- Porter, W. H., 17.
- Poulson, C. A., 21.
- Powell, E. H., 26.
- Power, J. B., 22, 47.
- Powers, H. C., 34.
- Powers, W. A., 14.
- Pratt, J. H., 33.
- Prentiss, A. N., 22, 47.
- Prentiss, R. W., 46.
- Price, D. T., 18.
- Price, M. A., 56.
- Price, R. B., 19.
- Primrose, W. S., 22.
- Price, R. C., 56.
- Price, R. H., 26, 54.
- Pritchard, S. R., 56.
- Pritchett, C. M., 47.
- Pryor, J. W., 38.
- Purinton, G. D., 43.
- Purnell, C. J., 16.
- Puryear, C., 54.
- Putzker, A., 31.
- Quaintance, A. L., 29.
- Quein, J. E., 23.
- Quick, W. J., 43.
- Ragland, E., 53.
- Ramsey, F. D., 57.
- Randall, H. I., 31.
- Randall, O. E., 51.
- Randolph, J. H., jr., 39.
- Randolph, L. S., 56.
- Rane, F. W., 27, 57.
- Ransome, F. L., 31.
- Raub, A. N., 12, 33.
- Raymond, I. S., 13.
- Raymond, W. J., 31.
- Read, A. C., 39.
- Read, G. A., 36.
- Read, L. C., 27, 57.
- Rearick, C. B., 43.
- Reber, L. E., 50.

Reddick, J. B., 10.
 Reddick, W. C., 47.
 Redding, R. J., 13.
 Redfearn, D. T., 24.
 Redifer, A. E., 50.
 Reed, J. H., 54.
 Renfrow, W. C., 23.
 Replogle, J., 37.
 Reynolds, M. H., 18, 42.
 Reynolds, P. B., 27, 57.
 Reynolds, W. F., 57.
 Rhodes, A., 22.
 Rice, C. J., 11.
 Rich, F. A., 26, 55.
 Rich, F. R., 32.
 Rich, J. T., 17.
 Richards, C. B., 32.
 Richards, C. R., 44.
 Richards, J. E., 56.
 Richman, E. S., 26, 55.
 Richter, A. W., 58.
 Riggs, W. M., 29.
 Riley, B. F., 35.
 Riley, C. V., 17.
 Riley, E. F., 27.
 Rising, W. B., 31.
 Ritter, M. B., 31.
 Ritter, W. E., 31.
 Roark, R. N., 38.
 Roberts, I. P., 22, 47.
 Roberts, M., 37.
 Robertson, W., 42.
 Robinson, F. H., 33.
 Robinson, J. A., 27.
 Robinson, J. S., 17, 40.
 Robinson, S. W., 48.
 Rodman, T. C., 51.
 Rogers, A., 10.
 Rogers, A. E., 40.
 Rogers, J. B., 20.
 Rolfe, C. W., 35.
 Rolfs, P. H., 12, 34.
 Roos, C., 39.
 Rose, A. J., 25.
 Ross, B. B., 9, 29, 60.
 Ross, C. H., 29.
 Ross, L. S., 25, 26, 54.
 Rossman, W. L., 18.
 Rothwell, G. F., 19.
 Rowell, C., 10.
 Rowell, J. C., 31.
 Rowlee, W. W., 47.
 Roy, V. L., 39.
 Royce, C. C., 11.
 Rumsey, W. E., 27.
 Runkle, E. W., 50.
 Rupp, A., 38.
 Rushin, J. M., 13.
 Russell, F. L., 16.
 Russell, H. L., 28, 58.
 Rust, R. C., 11.
 Rutledge, J. M., 43.
 Rutledge, T. T., 13.
 Ryals, G. M., 13.
 Ryan, C., 11.
 Ryan, C. J., 32.
 Ryan, J. J., 11.

Ryon, A. N., 19, 44.
 Salich, E., 44.
 Sample, W. A., 23.
 Sanborn, J. W., 26, 55.
 Sanford, T. F., 31.
 Saunders, A. R., 57.
 Saunders, W. M., 51.
 Saylor, C. F., 14.
 Sbisa, B., 54.
 Schermerhorn, A., 14.
 Schmitt, C. D., 53.
 Schurman, J. G., 22, 47.
 Schweitzer, P., 19, 43.
 Scott, A., 20, 21, 46, 51.
 Scott, C., 37.
 Scott, C. W., 45.
 Scott, E. L., 39.
 Scott, M. P., 40.
 Scott, W. H., 48.
 Scovell, M. A., 15, 59.
 Scoville, A. B., 56.
 Scribner, F. L., 25, 53.
 Sears, C. H., 52.
 Sears, L., 51.
 Secor, E., 14.
 Secrest, E., 15.
 Seibert, D., 16.
 Sells, C., 14.
 Senger, J. H., 31.
 Sessions, W. R., 17.
 Setchell, W. A., 32.
 Seth, J., 51.
 Seymour, W., 39.
 Shackelford, J., 38.
 Shaff, C. W., 13.
 Sharwood, W. J., 31.
 Shattuck, S. W., 35.
 Shaw, A. B., 14.
 Shaw, A. M., 16.
 Shaw, G. W., 49.
 Shaw, T., 18, 42.
 Sheib, E. E., 56.
 Sheffield, O. E., 35.
 Shelby, A. M., 15.
 Sheldon, C. H., 11.
 Sheldon, E. T., 25.
 Shepard, J. E., 55.
 Shepard, J. H., 25, 53.
 Shepardson, W. M., 17.
 Shepperd, J. H., 22, 47.
 Sherman, H. C., 40.
 Sherman, L. A., 44.
 Sherman, M. J., 56.
 Shinn, C. H., 10.
 Shipley, A. R., 23.
 Shiver, F. S., 25.
 Sholl, J. M., 55.
 Short, L. J., 33.
 Shumway, E. S., 46.
 Siebert, W. H., 48.
 Silvester, R. W., 17, 40.
 Simonds, W. E., 12.
 Simpson, R. W., 24.
 Sims, C. W., 25.
 Sirrene, F. A., 14.
 Skinner, B. S., 47.

Skolfield, H., 15, 39.
 Slate, F., 31.
 Sledge, A., 9.
 Slingerland, M. V., 22.
 Sloan, P. H. E., 24.
 Sloss, L., 10.
 Slosson, E. E., 28, 58.
 Small, C. H., 11.
 Smart, J. H., 14, 36.
 Smart, R. A., 36.
 Smith, A. J., 13.
 Smith, C. A., 39.
 Smith, C. D., 18, 22, 41.
 Smith, C. Y., 19.
 Smith, F., 35.
 Smith, J. B., 21, 46.
 Smith, H., 14.
 Smith, H. A., 32.
 Smith, H. B., 36.
 Smith, I. W., 37.
 Smith, J. R., 48.
 Smith, M. DeK., 16.
 Smith, O. D., 29.
 Smith, P. F., 32.
 Smith, R. F., 54.
 Smith, R. H., 17.
 Smith, S. I., 32.
 Smoke, S. A., 43.
 Smyth, E. A., jr., 27, 56.
 Snell, M. C., 49.
 Snelling, C. M., 35.
 Snodgrass, C. A., 43.
 Snow, C., 56.
 Snow, L. F., 51.
 Snyder, H., 18, 42.
 Solberg, A. C., 53.
 Sommerville, J. B., 27.
 Soule, F., 31.
 Southworth, C. M., 32.
 Sparks, E. E., 50.
 Spence, D. W., 54.
 Spence, T. H., 40.
 Spencer, G. L., 60.
 Sperr, F. W., 48.
 Speyers, C. L., 46.
 Spinney, L. B., 37.
 Spitzer, G., 36.
 Spurr, R. J., 15.
 Stackhouse, H. M., 24.
 Stadtmuller, F., 45.
 Stalker, M., 14, 37.
 Stanley, T. A., 58.
 Stannard, J. D., 11, 32.
 Stanton, E. W., 14, 37.
 Staples, S. B., 16, 39.
 Starkweather, G. P., 32.
 Starnes, H. N., 13.
 Stratford, E. D., 15.
 Stearns, J. W., 27.
 Stearns, O. P., 18.
 Stebbins, H., 10.
 Steele, C. L., 42.
 Stephenson, E. L., 46.
 Stevens, A. H., 33.
 Stevens, A. T., 18.
 Stevens, B. J., 27.

Stevens, J., 20.
 Stevens, J. S., 40.
 Stevens, M. C., 36.
 Stevens, P. F., 52.
 Stevens, W. E., 22.
 Stewart, F. C., 14, 37.
 Stewart, J. H., 27.
 Stiles, H. L., 43.
 Stinson, J. T., 10.
 Stockbridge, H. E., 59.
 Stockbridge, L., 41.
 Stockley, C. C., 12.
 Stoek, H. H., 50.
 Stollenwerck, G. D., 9.
 Stone, C. W., 20.
 Stone, D. E., 20.
 Stone, E. P., 20.
 Stone, G. E., 41.
 Stone, W. E., 36.
 Stone, J. M., 18.
 Stout, O. V. P., 44.
 Stover, W. R., 26.
 Strachen, W. J., 11.
 Strahan, C. M., 35.
 Stratford, E. D., 15.
 Straughn, C. E., 40.
 Street, H. M., 18.
 Street, J. P., 20, 60.
 Street, W. D., 15.
 Strickler, H. M., 40.
 Stringer, S., 12.
 Stringham, I., 31.
 Strode, H. A., 52.
 Strong, W. C., 17.
 Strout, M. D., 36.
 Stuart, C. B., 14.
 Stuart, J. A., 9.
 Stuart, J. M., 34.
 Stubbs, J. T., 12.
 Stubbs, W. C., 16, 39, 60.
 Stubenrauch, A. V., 10.
 Stuermer, J., 36.
 Stull, J. W., 56.
 Sturgis, W. C., 11.
 Styer, H. D., 55.
 Sutton, J., 31.
 Swan, E. D., 36.
 Swayzee, R. B., 43.
 Sweetser, W. S., 24.
 Switzler, I., 19.

Taff, S., 30.
 Taft, L. R., 18, 41.
 Taggart, W. M., 50.
 Talbott, E., 28.
 Talbott, E. H., 19.
 Taliaferro, W. T. L., 40.
 Tallant, J. G., 20.
 Talley, T. W., 34.
 Tannatt, T. R., 27.
 Taylor, E., 13.
 Taylor, G. H., 20.
 Taylor, J. R., 48.
 Taylor, L. M., 11, 32.
 Taylor, W. D., 39.
 Taylor, W. G., 44.

- Teeple, G. L., 45.
 Teller, G. L., 10.
 Temple, O. P., 25.
 Tenney, H., 9.
 Terrill, J. S., 15.
 Test, E., 36.
 Test, W. H., 36.
 Thach, C. C., 29.
 Thayer, W. C., 50.
 Thomas, B. F., 48.
 Thompson, C. D., 49.
 Thompson, C. K., 39.
 Thompson, H. E., 49.
 Thompson, H. M., 17.
 Thompson, J. D., 36.
 Thompson, J. S. C., 33.
 Thompson, M. J., 50.
 Thorne, C. E., 23.
 Thresher, H. H., 52.
 Throop, L. S., 55.
 Thurlimann, L., 37.
 Thurtell, H., 45.
 Tillinghast, P., 13.
 Tillman, B. R., 24.
 Tilson, P. S., 26, 54.
 Tindal, J. E., 24.
 Tine, B. F., 20.
 Titsworth, A. A., 46.
 Titus, R., 20.
 Tofthagen, A. M., 22.
 Tompkins, D. A., 22.
 Tompkins, S., 52.
 Torreyson, J. D., 20.
 Toumey, J. W., 9, 30.
 Towar, J. D., 24.
 Townsend, E. J., 35.
 Townshend, N. S., 48.
 Towle, W. M., 50.
 Tracy, J. C., 32.
 Tracy, S. M., 18.
 Trammel, R. J., 29.
 Traphagen, F. W., 19, 44.
 Tremain, M. A., 44.
 Tremaine, J., 44.
 Trimble, R. E., 11, 32.
 Troop, J., 14, 36.
 Troyer, A. M., 19.
 Tucker, C. B., 34.
 Tucker, C. C., 56.
 Tucker, T. DeS., 34.
 Turnbull, S. J., 12.
 Turner, H. B., 56.
 Turner, W. P., 36.
 Tutherly, H. E., 55.
 Tuttle, A., 21.
 Tuttle, F. E., 50.
 Twitty, J. N., 13.
 Twombly, S. S., 26, 55.
 Tyler, Mrs. A. M., 30.
 Tyson, H., 10.
 Tyson, L. D., 53.
 Upson, I. S., 20, 21, 46.
 Upton, W., 51.
 Vagner, C. L., 28.
 Van Blarcom, H., 43.
 Vanderford, C. F., 25, 53.
 Vandiver, A. C., 19.
 Vandiver, M., 16.
 Vandoren, N. L., 57.
 Van Dyck, F. C., 46.
 Van Dyke, J. C., 46.
 Van Gorder, A. G., 31.
 Van Slyke, L. L., 21.
 Van Weller, P., 34.
 Vawter, C. E., 26.
 Vedder, H. K., 41.
 Veeder, J. D. W., 21.
 Venable, A. R., 26.
 Verrill, A. E., 32.
 Von Holland, A., 36.
 Voorhees, E. B., 20, 46, 59, 60.
 Voorhees, L. A., 20.
 Votey, J. W., 55.
 Vye, J. A., 18, 42.
 Wait, C. E., 53.
 Waite, D. H., 11.
 Waitt, Mrs. J. H., 16.
 Wakeman, A. J., 32.
 Walden, P. T., 33.
 Waldron, C. B., 22, 47.
 Waldron, M. M., 56.
 Walker, B. M., 42.
 Walker, C. S., 41.
 Walker, F., 58.
 Walker, M., 9.
 Walker, Mark, 9.
 Walker, W. S., 50.
 Wallace, H. C., 14, 37.
 Wallace, J. S., 42.
 Wallace, W. T., 10.
 Waller, O. L., 57.
 Walters, J. D., 38.
 Wannamaker, J. E., 24.
 Ward, H. B., 44.
 Ward, W. R., 20.
 Warder, R. H., 23.
 Warner, C. D., 17, 41.
 Warren, W. H., 13.
 Washburn, A. C., 41.
 Washburn, F. L., 23, 49.
 Washburn, J. H., 24, 51, 59.
 Washburn, L. C., 12.
 Washington, M. E., 30.
 Wason, G. A., 20.
 Waterman, G. A., 33.
 Waters, C. R., 53.
 Waters, H. J., 24, 50.
 Watkins, W. W., 13.
 Watrous, F. L., 11.
 Watson, G. C., 22, 47.
 Watson, E. J., 16, 51.
 Watson, T. I., 16.
 Watson, T. L., 27, 56.
 Watt, G. H., 57.
 Watts, J. B., 54.
 Watts, R. L., 25, 53.
 Waugh, C. V., 34.
 Waugh, F. A., 23, 49.
 Waymire, J. A., 10.
 Weatherford, J. K., 23.
 Webb, H. S., 40.

- Webb, J. F., 29.
 Webb, J. H., 11.
 Webb, W., 34.
 Weber, H. A., 48.
 Webster, F. M., 23.
 Webster, W. T., 23.
 Weed, C. M., 20, 45, 59.
 Weed, H. E., 18.
 Wegener, A. B., 53.
 Weick, C. W., 48.
 Weihe, F. A., 33.
 Weil, C. L., 41.
 Welborn, W. C., 42.
 Welch, C. W., 52.
 Welch, W., 52.
 Weld, R. J., 24.
 Wellington, C., 41.
 Wells, F., 17.
 Wells, H. L., 33.
 Wells, J. H., 38.
 Wentch, J. A., 37.
 Wentzel, D., 17.
 Werner, W. C., 48.
 Wertz, G. T., 20.
 Westcott, A. L., 41.
 Weston, C., 19.
 Westermann, G., 37.
 Whalen, W. H., 47.
 Wharton, R. W., 22.
 Wheaton, A. H., 25.
 Wheaton, H. H., 53.
 Wheeler, A. S., 33.
 Wheeler, C. F., 18, 41.
 Wheeler, H. J., 51.
 Wheeler, J., 15.
 Wheeler, W., 17.
 Wheeler, W. P., 21.
 Wheeler, H. J., 24, 60.
 Whitaker, M. A., 20.
 Whitche, G. H., 20, 45.
 White, A. D., 22.
 White, A. H., 35.
 White, B. O., 26.
 White, D. S., 48.
 White, F. H., 38.
 White, H. C., 13, 35, 59.
 White, J. C., 19, 44.
 White, J. G., 38.
 White, J. M., 42.
 Whitehill, A. R., 57.
 Whiting, N., 31.
 Whitlock, R. H., 54.
 Whitner, J. N., 12, 34.
 Whitney, M., 17.
 Whitney, W. D., 32.
 Wickson, E. J., 10, 31.
 Wjechardt, A. J., 46.
 Wiggin, O. C., 51.
 Wightman, A. R., 51.
 Wilcox, C. P., 35.
 Wilder, K., 44.
 Wildman, B. E., 23.
 Wiley, E., 53.
 Wiley, H. W., 60.
 Willard, J. J., 50.
 Willard, J. M., 50.
 Willard, J. T., 15, 38.
 Willey, W. P., 57.
 Williams, A., 51.
 Williams, A. W., 25, 53.
 Williams, C. B., 22, 47.
 Williams, C. M., 32.
 Williams, E. L., 22.
 Williams, G. J., 43.
 Williams, L., 43.
 Williams, N. J., 30.
 Williams, J. P., 47.
 Williams, T. A., 25, 53.
 Williams, W. L., 19, 44.
 Williams, W. R., 22.
 Willis, R. H., 30.
 Wilmore, J. J., 29.
 Wills, J. H., 29.
 Willson, L. S., 19.
 Wilson, A. M., 44.
 Wilson, C. C., 33.
 Wilson, E., 37.
 Wilson, E. T., 48.
 Wilson, F., 37.
 Wilson, G. G., 51.
 Wilson, J., 14, 37.
 Wilson, M. E., 33.
 Wilson, N. E., 20.
 Winchip, Mrs. E. E., 38.
 Wing, H. H., 22, 47.
 Wing, H. J., 13, 35.
 Winn, F. L., 31.
 Winslow, I. O., 16.
 Winslow, L. E., 25, 53.
 Winton, A. L., jr., 11.
 Wismer, F., 58.
 Withers, J. S., 27.
 Withers, W. A., 47.
 Wolf, T. R., 33.
 Wolfe, H. K., 44.
 Wolfe, J. M., 50.
 Woll, F. W., 28, 58.
 Wood, A. H., 20, 45.
 Wood, E. W., 17.
 Wood, J. H., 14.
 Woodbury, H. E., 33.
 Woodruff, W. B., 54.
 Woods, C. D., 12, 60.
 Wooton, E. O., 21, 46.
 Woodward, J. A., 24.
 Woodworth, C. W., 10, 31.
 Woodworth, P. B., 41.
 Worcester, J. S., 56.
 Worden, L. D., 36.
 Working, D. W., 11, 32.
 Wright, R. E., 56.
 Wright, S. G., 14, 36.
 Yarborough, L. T., 47.
 Yates, R. E. L., 47.
 Yocum, W. F., 34.
 Zimmerman, W. H., 40.

PUBLICATIONS OF THE OFFICE OF EXPERIMENT STATIONS.

The Office of Experiment Stations issues three classes of publications for general distribution:

(1) Experiment Station Record and (2) Bulletins, which are more or less technical. It is the practice to send to persons applying for them one or more numbers, from which they may judge of their usefulness, but not to place any names upon the mailing list until after receipt of applications on special blanks furnished by the Office.

(3) Farmers' Bulletins, which are brief and popular in character, and are sent on application. These bulletins are issued as part of the general series of Farmers' Bulletins of the Department of Agriculture.

The following publications have been issued:

Experiment Station Record, Vol. I, 6 numbers; Vol. II, 12 numbers; Vol. III, 12 numbers and index; Vol. IV, 12 numbers; Vol. V, Nos. 1-5. Copies of the station and Department publications abstracted in the Record can, in many instances, be obtained on application.

Experiment Station Bulletins.—No. 1, Organization and History of the Stations; No. 2, Digest of Annual Reports of the Stations for 1888, in two parts; No. 3, Report of Meeting of Horticulturists at Columbus, Ohio, June, 1889; No. 4, List of Station Horticulturists and Outline of their Work; No. 5, Organization Lists of Stations and Colleges, March, 1890; No. 6, List of Station Botanists and Outline of their Work; No. 7, Proceedings of the Fifth Annual Convention of the Association of American Agricultural Colleges and Experiment Stations, Washington, D. C., August, 1891; No. 8, Lectures on Investigations at Rothamsted Experimental Station; No. 9, The Fermentations of Milk; No. 10, Meteorological Work for Agricultural Institutions; No. 11, A Compilation of Analyses of American Feeding Stuffs; No. 12, Organization Lists of the Agricultural Experiment Stations and Agricultural Schools and Colleges in the United States, June, 1892; No. 13, Organization Lists of the Agricultural Experiment Stations and Agricultural Schools and Colleges in the United States, April, 1893; No. 14, Proceedings of a Convention of the National League for Good Roads, March, 1893; No. 15, Handbook of Experiment Station Work; No. 16, Proceedings of the Sixth Annual Convention of the Association of American Agricultural Colleges and Experiment Stations, November, 1892; No. 17, Suggestions for the Establishment of Food Laboratories; No. 18, The Assimilation of Atmospheric Nitrogen by Black and White Mustard.

Miscellaneous Bulletins.—No. 1, Proceedings of Knoxville Convention of Association of Agricultural Colleges and Stations, January, 1889; No. 2, Proceedings of Washington Convention of the Association, November, 1889; No. 3, Proceedings of Champaign Convention of the Association, November, 1890. (Series discontinued.)

Farmers' Bulletins.—No. 1, The What and Why of Agricultural Experiment Stations; No. 2, Illustrations of the Work of the Stations; No. 9, Milk Fermentations and their Relation to Dairying; No. 11, The Rape Plant.

Communications intended for this Office should be addressed to the SECRETARY OF AGRICULTURE, for the *Office of Experiment Stations, Department of Agriculture, Washington, D. C.*

U. S. DEPARTMENT OF AGRICULTURE
OFFICE OF EXPERIMENT STATIONS

BULLETIN No. 20

PROCEEDINGS

OF THE

SEVENTH ANNUAL CONVENTION

OF THE ASSOCIATION OF

American Agricultural Colleges and Experiment Stations

HELD AT

CHICAGO, ILLINOIS

OCTOBER 17-19, 1893

EDITED BY

A. C. TRUE, for the Office of Experiment Stations

AND

H. E. ALVORD, for the Executive Committee of the Association

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE

WASHINGTON
GOVERNMENT PRINTING OFFICE
1894

OFFICE OF EXPERIMENT STATIONS.

A. C. TRUE, Director.

E. W. ALLEN, Assistant Director and Editor of departments of Chemistry, Foods and Animal Production, and Dairying.

W. H. BEAL, Editor of departments of Meteorology, Fertilizers, Soils, and Indexes.

WALTER H. EVANS, Editor of departments of Botany, Seeds, Weeds, and Diseases of Plants.

J. F. DUGGAR, Editor of departments of Field Crops and Veterinary Science and Practice.

F. C. TEST, Editor of departments of Horticulture and Entomology.

W. O. ATWATER, Special Agent.

R. B. HANDY, Special Agent.

F. H. HALL, Librarian.

S. L. SOMMERS, Record Clerk.

THE AGRICULTURAL EXPERIMENT STATIONS.

ALABAMA—*Auburn*: College Station; W. L. Broun.† *Uniontown*: Canebrake Station; H. Benton.‡

ARIZONA—*Tucson*: T. B. Comstock. §

ARKANSAS—*Fayetteville*: R. L. Bennett. *

CALIFORNIA—*Berkeley*: E. W. Hilgard. *

COLORADO—*Fort Collins*: Alston Ellis. *

CONNECTICUT—*New Haven*: State Station; S. W. Johnson. * *Storrs*: Storrs Station; W. O. Atwater. *

DELAWARE—*Newark*: A. T. Neale. *

FLORIDA—*Lake City*: O. Clute. *

GEORGIA—*Experiment*: R. J. Redding. *

IDAHO—*Moscow*: C. P. Fox. *

ILLINOIS—*Champaign*: G. E. Morrow. †

INDIANA—*Lafayette*: C. S. Plumb. *

IOWA—*Ames*: James Wilson. *

KANSAS—*Manhattan*: G. T. Fairchild. §

KENTUCKY—*Lexington*: M. A. Scovell. *

LOUISIANA—*Audubon Park, New Orleans*: Sugar Station. *Baton Rouge*: State Station. *Calhoun*: North Louisiana Station; W. C. Stubbs. *

MAINE—*Orono*: W. H. Jordan. *

MARYLAND—*College Park*: R. H. Miller. *

MASSACHUSETTS—*Amherst*: State Station; C. A. Goessmann. * *Amherst*: Hatch Station; H. H. Goodell. *

MICHIGAN—*Agricultural College*: L. G. Gorton. *

MINNESOTA—*St. Anthony Park*: W. M. Liggett. §

MISSISSIPPI—*Agricultural College*: S. M. Tracy. *

MISSOURI—*Columbia*: E. D. Porter. *

MONTANA—*Bozeman*: S. M. Emery. *

NEBRASKA—*Lincoln*: C. L. Ingersoll. *

NEVADA—*Reno*: S. A. Jones. *

NEW HAMPSHIRE—*Durham*: G. H. Whitcher. *

NEW JERSEY—*New Brunswick*: State Station; E. B. Voorhees. * *New Brunswick*: College Station; A. Scott. *

NEW MEXICO—*Las Cruces*: H. Hadley. *

NEW YORK—*Geneva*: State Station; P. Collier. * *Ithaca*: Cornell University Station; I. P. Roberts. *

NORTH CAROLINA—*Raleigh*: H. B. Battle. *

NORTH DAKOTA—*Fargo*: J. B. Power. *

OHIO—*Wooster*: C. E. Thorne. *

OKLAHOMA—*Stillwater*: J. C. Neal. *

OREGON—*Corvallis*: J. M. Bloss. *

PENNSYLVANIA—*State College*: H. P. Armsby. *

RHODE ISLAND—*Kingston*: C. O. Flagg. *

SOUTH CAROLINA—*Clemson College*: E. B. Craighead. *

SOUTH DAKOTA—*Brookings*: L. McLouth. §

TENNESSEE—*Knoxville*: C. F. Vanderford. ||

TEXAS—*College Station*: J. H. Connell. *

UTAH—*Logan*: J. H. Paul. *

VERMONT—*Burlington*: J. L. Hills. *

VIRGINIA—*Blacksburg*: J. M. McBryde. *

WASHINGTON—*Pullman*: E. A. Bryan. *

WEST VIRGINIA—*Morgantown*: J. A. Myers. *

WISCONSIN—*Madison*: W. A. Henry. *

WYOMING—*Laramie*: A. A. Johnson. *

* Director.

† President of board of direction.

‡ Assistant director in charge.

§ Chairman of council.

|| Secretary.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., June 5, 1894.

SIR: I have the honor to transmit herewith for publication Bulletin No. 20 of this Office, containing the proceedings of the seventh annual convention of the Association of American Agricultural Colleges and Experiment Stations, held at Chicago, Ill., October 17-19, 1893. The stenographic report of this meeting was made by Mr. S. E. Black, of this Office.

Respectfully,

A. C. TRUE,
Director.

Hon. J. STERLING MORTON,
Secretary of Agriculture.

CONTENTS.

	Page.
Letter of transmittal	6
Constitution of the Association of American Agricultural Colleges and Experiment Stations	7
Officers of the association	11
List of delegates and visitors in attendance	13
Call for the convention	16
Program	17
Proceedings	19
Report of the executive committee	19
Report of the treasurer of the Association	22
Report of the Section on College Work. "The work in military science in land-grant colleges and its needs." By Charles W. Dabney, jr	25
Report on uniformity of station publications	30
Report on the collective station exhibit	34
President's address	38
Agricultural investigations at Rothamsted, England. By Sir Joseph Henry Gilbert	46
Report of the committee on dairy tests	52
How can we increase the attendance of station officers at our annual conventions? By C. E. Thorne	61
Shopwork instruction at the Iowa State College of Agriculture and the Mechanic Arts, Ames, Iowa. By G. W. Bissell	65
Technical education. By C. W. Hall	67
The manual training and the apprentice system. By C. Russ Richards	73
Mechanical drawing in technical schools. By J. J. Flather	81
Appendix (minutes of sections):	
Section on Agriculture and Chemistry	91
Section on College Work	92
Section on Horticulture and Botany	93
The Solandi printing. By B. D. Halsted	93
Field observations with fungi. By B. D. Halsted	93
Section on Mechanic Arts	95
Index	97
Name list	97
Subject list	99

CONSTITUTION

OF THE

ASSOCIATION OF AMERICAN AGRICULTURAL COLLEGES AND EXPERIMENT STATIONS.

NAME.

This Association shall be called the Association of American Agricultural Colleges and Experiment Stations.

OBJECT.

The object of this Association shall be the consideration and discussion of all questions pertaining to the successful progress and administration of the colleges and stations included in the Association, and to secure to that end mutual coöperation.

MEMBERSHIP.

(1) Every college established under the act of Congress approved July 2, 1862, or receiving the benefits of the act of Congress approved August 30, 1890, and every agricultural experiment station established under State or Congressional authority, the Bureau of Education of the Department of the Interior, the Department of Agriculture, and the Office of Experiment Stations of the last-named Department, shall be eligible to membership in this Association.

(2) Any institution a member of the Association in full standing may send any number of delegates to the meetings of the Association, but one shall be designated to the Association as the regular representative and voting delegate. The same delegate may represent both a college and a station, but shall cast only one vote in general sessions. Other delegates may be designated by any institution to represent it in specified sections of the Association, but such delegates shall vote only in such sections, and no institution shall be allowed more than one vote in any sectional meeting.

(3) Delegates from other institutions engaged in educational or experimental work in the interest of agriculture or mechanic arts may, by a majority vote, be admitted to conventions of the Association, with all privileges except the right to vote.

(4) In like manner, any person engaged or directly interested in agriculture or mechanic arts who shall attend any convention of this Association may be admitted to similar privileges.

SECTIONS.

(1) The Association shall be organized into sections upon (1) college work; (2) agriculture and chemistry; (2) horticulture and botany; (4) entomology; (5) mechanic arts. The executive committee shall, upon the request of any ten institutions represented in the Association, provide for the organization of provisional sections at any convention.

(2) Each section shall conduct its own proceedings and shall keep record of the same, and present a synopsis thereof to the Association at the close of every convention; and no action of a section, by resolution or otherwise, shall be valid until the same shall have been ratified by the Association in general session.

MEETINGS.

(1) This Association shall hold at least one meeting in every calendar year, to be designated as the annual convention of the Association. Special meetings may be held at other times, upon the call of the executive committee, for purposes to be specified in the call.

(2) The annual convention of the Association shall comprise general sessions and meetings of the sections, and provision shall be made therefor in the program. The section meetings may be simultaneous or otherwise, at the discretion of the executive committee, but at least two sections of the Association, to be designated each year by the executive committee, shall present in general session of each convention a portion of the subjects coming before them.

OFFICERS.

(1) The general officers of this Association shall be a president, five vice-presidents, a bibliographer, and a secretary, who shall also be treasurer. The president, junior ex-president, the secretary, and four persons to be chosen by the Association shall constitute an executive committee, which shall elect its own chairman.

(2) Each section shall, by ballot, nominate to the Association in general session, for its action, a chairman and a secretary for such section.

(3) Officers shall be chosen by ballot at the annual convention of the Association, and shall hold office from the close of the convention at which they are elected until their successors shall be chosen.

(4) Any person being an accredited delegate to an annual meeting of the Association, or an officer of an institution which is a member of the Association in full standing at the time of election, shall be eligible to office.

DUTIES OF OFFICERS.

(1) The officers of the Association shall perform the duties which usually devolve upon their respective offices.

(2) The president shall deliver an address at the annual convention before the Association in general session.

(3) The chairman of each section shall make, at the annual convention, a report to the Association in general session of the progress during the preceding year of the subject or subjects appertaining to his section, and such reports shall not occupy more than twenty minutes each.

(4) The executive committee shall determine the time and place of the annual conventions and other meetings of the Association, and shall, between such conventions and meetings, act for the Association in all matters of business. It shall issue its call for the annual conventions of the Association not less than sixty days before the date on which they are to be held, and for special meetings not less than ten days before such dates. It shall be charged with the general arrangement and conduct of all meetings called by it. It shall designate the two sections to present in general session a portion of the subjects coming before them, and shall give notice thereof to the chairmen of such sections at least ninety days prior to the annual convention. It shall provide a well-prepared order of business and a program of exercises, and shall make a seasonable issue of said program. Said committee may fill any vacancy in an office or committee of the Association occurring after the adjournment of the annual convention, such appointee to serve until the next annual election.

FINANCES.

At every annual convention, the Association, in general session, shall provide for obtaining the funds necessary for its legitimate expenses, and may, by appropriate action, call for contributions upon the several institutions eligible to membership; and no institution shall be entitled to representation or participation in the benefits of the Association unless such institution shall have made the designated contribution for the year previous to that in and for which such question of privilege shall arise, or shall have had said payment remitted by the unanimous vote of the executive committee.

AMENDMENTS.

This constitution may be amended at any regular convention of the Association by a two-thirds vote of the delegates present, if the number constitute a quorum: *Provided*, That notice of any proposed amendment, together with the full text thereof and the name of the mover, shall have been given in the call for the convention. Every such proposition of amendment shall be subject to modification or amendment in the same manner as other propositions, and the final vote on the adoption or rejection shall be taken by yeas and nays of the institutions then and there represented.

RULES OF ORDER.

(1) The executive committee shall be charged with the order of business, subject to special action of the convention, and this committee may report at any time.

(2) All business or topics proposed for discussion and all resolutions submitted for consideration of the convention shall be read and then referred, without debate, to the executive committee, to be assigned positions on the program.

(3) Speakers invited to open discussions shall be entitled to twenty minutes each.

(4) In general discussions the ten-minute rule shall be enforced.

(5) No speaker shall be recognized a second time on any one subject while any delegate who has not spoken thereon desires to do so.

(6) The hours of meeting and adjournment adopted with the general program shall be closely observed, unless changed by a two-thirds vote of delegates present.

(7) The presiding officer shall enforce the parliamentary rules usual in such assemblies and not inconsistent with the foregoing.

OFFICERS OF THE ASSOCIATION OF AMERICAN AGRICULTURAL
COLLEGES AND EXPERIMENT STATIONS.

President :

S. D. LEE, of Mississippi.

Vice-Presidents :

G. E. MORROW, of Illinois; H. HADLEY, of New Mexico;
J. S. NEWMAN, of South Carolina; J. H. CANFIELD, of Nebraska;
WILLIAM FREAR, of Pennsylvania.

Secretary and Treasurer :

M. A. SCOVELL, of Kentucky.

Bibliographer :

S. W. JOHNSON, of Connecticut.

Executive Committee :

The PRESIDENT; the JUNIOR EX-PRESIDENT (W. A. Henry, of Wisconsin); the
SECRETARY;
H. E. ALVORD, the District of Columbia; A. W. HARRIS, of Maine;
H. C. WHITE, of Georgia; H. H. GOODELL, of Massachusetts.

Chairmen of Sections :

Agriculture and Chemistry, W. A. HENRY, of Wisconsin; College Work, GEO. T. FAIRCHILD, of
Kansas;
Botany and Horticulture, E. S. GOFF, of Wisconsin; Entomology, H. OSBORN, of Iowa;
Mechanic Arts, J. H. WASHBURN, of
Rhode Island.

Secretaries of Sections :

Agriculture and Chemistry, E. B. VOORHEES, of New Jersey; College Work, H. E. STOCKBRIDGE, of
North Dakota;
Botany and Horticulture, L. H. PAMMEL, of Iowa; Entomology, C. M. WEED, of New Hamp-
shire;
Mechanic Arts, F. P. ANDERSON, of Kentucky.

LIST OF DELEGATES AND VISITORS IN ATTENDANCE.

Alabama:

College: A. J. Bondurant, professor of agriculture.

Arizona:

Station: F. A. Gulley, director.

Arkansas:

Station: R. L. Bennett, director.

Colorado:

College: A. L. Kellogg, trustee.

Station: C. P. Gillette, entomologist.

Connecticut:

College: Storrs—B. F. Koons, president; E. H. Hyde, trustee.

Station: State—W. C. Sturgis, mycologist.

Georgia:

College: J. B. Hunnicutt, professor of agriculture.

Station: H. N. Starnes, horticulturist.

Idaho:

Station: J. M. Jones, superintendent substation.

Illinois:

College: G. E. Morrow, dean of agriculture; I. S. Raymond, trustee.

Station: E. H. Farrington, chemist.

Indiana:

College: H. A. Huston, professor of agricultural chemistry.

Station: C. S. Plumb, director.

Iowa:

College: L. H. Pammel, professor of botany.

Station: James Wilson, director; C. F. Curtiss, assistant director.

Kansas:

College: G. T. Fairchild, president; Joshua Wheeler, regent; W. D. Street, regent; N. S. Mayo, professor of veterinary science and physiology.

Kentucky:

College: J. K. Patterson, president; F. P. Anderson, professor of mechanical engineering; W. A. Patterson, tutor.

Station: M. A. Scovell, director.

Louisiana:

College (Southern University, New Orleans): Hugh Jamieson, jr., professor of agriculture.

Maine:

College: A. W. Harris, president.

Station: Walter Balentine, agriculturist.

Maryland:

College: R. W. Silvester, president; W. T. L. Taliaferro, professor of agriculture.

Station: R. H. Miller, director.

Massachusetts:*College:* W. H. Bowker, trustee.*Station:* State—C. A. Goessmann, director.**Michigan:***College:* C. D. Smith, professor of agriculture; A. C. Glidden, trustee.**Minnesota:***College:* M. H. Reynolds, professor of veterinary science.*Station:* W. M. Hays, agriculturist.**Mississippi:***College:* W. C. Welborn, professor of agriculture; C. L. Steele, professor of military science and tactics.*Station:* W. L. McGee, assistant director.**Missouri:***College:* E. D. Porter, dean.**Montana:***Station:* S. M. Emery, director.**New Jersey:***College:* Austin Scott, president.**New Hampshire:***College:* C. S. Murkland, president.**New Mexico:***College:* Hiram Hadley, president.*Station:* J. D. W. Veeder, member board of control.**New York:***College:* J. H. Comstock, professor of entomology.*Station:* Cornell—I. P. Roberts, director.**North Carolina:***Station:* H. B. Battle, director.**North Dakota:***College:* H. E. Stockbridge, president.*Station:* T. D. Hinebaugh, veterinarian.**Ohio:***College:* W. R. Lazenby, professor of horticulture; Thos. F. Hunt, professor of agriculture; N. S. Townshend, *emeritus* professor of agriculture; H. A. Weber, professor of agricultural chemistry; H. J. Detmers, professor of veterinary surgery.*Station:* C. E. Thorne, director; J. F. Hickman, agriculturist; S. H. Ellis, R. H. Warder, J. H. Brigham, members board of control.**Oklahoma:***College:* A. C. Magruder, professor of agriculture.**Pennsylvania:***College:* G. W. Atherton, president; W. H. Caldwell, assistant professor of agriculture.*Station:* H. P. Armsby, director; W. Frear, vice-director and chemist.**Rhode Island:***College:* J. H. Washburn, president.*Station:* C. O. Flagg, director.**South Carolina:***College:* E. B. Craighead, president.**South Dakota:***College:* L. McLouth, president.**Tennessee:***College:* C. W. Dabney, jr., president.*Station:* C. F. Vanderford, secretary.**Texas:***College:* A. J. Rose, W. R. Cavitt, trustees.

Vermont:

Station : J. L. Hills, director.

West Virginia:

College : J. A. Robinson, J. S. Withers, trustees.

Station : J. A. Myers, director.

Wisconsin:

College : W. A. Henry, dean.

Station : F. W. Woll, assistant chemist.

Wyoming:

College : G. R. Hebard, secretary board of trustees.

Station : B. C. Buffum, horticulturist and meteorologist.

U. S. Department of Agriculture:

H. E. Alvord, special agent.

Office of Experiment Stations:

A. C. True, director; S. E. Black, private secretary.

Bureau of Education:

J. W. Holcombe, chief clerk.

Canada:

Ontario Agricultural College : C. A. Zavitz.

Provincial School of Agriculture : H. W. Smith, principal.

CALL FOR THE CONVENTION.

By authority of the executive committee a delegate convention of this Association is hereby called to meet in the city of Chicago, Ill., on Tuesday, October 17, 1893, at 10 o'clock a. m.

Attention is called to Article III of the revised constitution of the Association, entitled "Membership," and which is as follows:

(1) Every college established under the act of Congress approved July 2, 1862, or receiving the benefits of the act of Congress approved August 30, 1890, and every agricultural experiment station established under State or Congressional authority, the Bureau of Education of the Department of the Interior, the Department of Agriculture, and the Office of Experiment Stations of the last-named Department shall be eligible to membership in this Association.

(2) Any institution a member of the Association in full standing may send any number of delegates to the meetings of the Association, but one shall be designated to the Association as the regular representative and voting delegate. The same delegate may represent both a college and a station, but shall cast only one vote in general sessions. Other delegates may be designated by any institution to represent it in specified sections of the Association, but such delegates shall vote only in such sections, and no institution shall be allowed more than one vote in any sectional meeting.

(3) Delegates from other institutions engaged in educational or experimental work in the interest of agriculture may, by a majority vote, be admitted to conventions of the Association, with all privileges except the right to vote.

(4) In like manner, any person engaged or directly interested in agriculture who shall attend any convention of this Association may be admitted to similar privileges.

In accordance with Article VII, the Section on Agriculture and Chemistry and the Section on Mechanic Arts are designated "to present in general session a portion of the subjects coming before them."

The program for the session and other particulars will be announced later.

The several agricultural congresses of the World's Congress Auxiliary of the Columbian Exposition will be held in Chicago, October 16-28, and it is intended that the sessions of this Association shall be arranged in harmony therewith.

For the executive committee:

HENRY E. ALVORD,
Chairman.

M. A. SCOVELL,
Secretary.

WASHINGTON, D. C., *July 15, 1893.*

PROGRAM.

TUESDAY, OCTOBER 17, 1893.

10 a. m.—General session. Organization, committee reports, etc.

2 p. m.—Meetings of the sections for business and further arrangements.

8 p. m.—General session. In union with the World's Agricultural Congress.

1. Annual address by the President of the Association.
2. Introduction of Sir Henry Gilbert, special delegate from the Lawes Agricultural Trust, Rothamsted, England.

WEDNESDAY, OCTOBER 18, 1893.

10 a. m.—General session for business, election of officers, etc.

Subject for discussion and action: The Association and the Exposition.

2 p. m.—Meetings of all the sections.

7 p. m.—General session.

1. Subjects presented by Section on Agriculture and Chemistry.
2. Subjects presented by the Section on Mechanic Arts.
3. Final adjournment of general session, unless otherwise ordered.

THURSDAY, OCTOBER 19, 1893.

10 a. m., 2 p. m., and 7 p. m.—Meetings of the sections.

The World's Agricultural Congresses hold sessions on the afternoons and evenings of the same week.

PROCEEDINGS.

MORNING SESSION, TUESDAY, OCTOBER 17, 1893.

The convention was called to order at 10:20 a. m., in room No. 4, Art Institute, on the Lake front, head of Adams street, Chicago, by President Henry.

The PRESIDENT. Gentlemen: In accordance with the call of the executive committee, issued July 15, we have met for this, the seventh, annual convention of the Association of American Agricultural Colleges and Experiment Stations. Allow me to call your attention to the report of the proceedings of our last convention, held at New Orleans last November, copies of which most of you probably received before leaving home. It has been suggested that the section of the constitution relating to membership be read, and I will call on the secretary to read it.

The secretary read the section of the constitution relating to membership.

The report of the executive committee was submitted by Henry E. Alvord, chairman.

REPORT OF THE EXECUTIVE COMMITTEE.

Immediately after the adjournment of the convention of 1892 this committee met at New Orleans and organized, selecting Henry E. Alvord as chairman and M. A. Scovell as secretary.

The committee has performed the duties with which it was charged by the last convention, as far as practicable, and, in accordance with the revised constitution of the Association, has called the present meeting and made the necessary arrangements therefor. A very general expression of preference for Chicago made it an easy matter to decide upon this city as the place of meeting. There was some difference of opinion as to the time, but it was decided in order to accord with the previous assignment of the World's Agricultural Congress to the period from October 16 to 20, inclusive. In consideration of the attractions of the World's Columbian Exposition and of the Congress mentioned, it has been deemed expedient to reduce the program for the convention to the minimum consistent with the constitution, so far as general sessions are concerned, and to leave the several sections to decide for themselves the character and duration of their sessions. These considerations have made it impracticable to conform closely this year to the suggestions contained in two resolutions regarding the length and character of the annual convention, which were referred at New Orleans to this committee.

Since the last convention there has been little for this committee to do except to execute the instructions of that convention. The main work has been in connection with the interests of the Association and the institutions represented by it at the Columbian Exposition.

The standing committees in charge of the collective exhibits of the colleges and stations were greatly aided and supported in their work by the advisory board elected by the New Orleans convention. It may be remarked in passing that this experience shows the advantage of having members of the governing boards appointed as delegates from our different institutions, and of bringing them into the active work of the Association.

The executive committee in charge of the collective college exhibit found that, notwithstanding the active coöperation of many of the colleges and such assistance as the Department of Agriculture was able to give, it would be necessary to have special funds to make this exhibit a success. Senator Morrill and the advisory board were very helpful in this matter, and an appropriation of \$8,000 was obtained from Congress, to be disbursed under the supervision of the Department of Agriculture. That Department appointed as its special agent for this business the chairman of the Association committee, and the work of collecting and placing this college exhibit, although late, was carried to completion in a manner which, it is hoped, may meet with the approbation of those interested. Every college prepared and packed its own contributions, defraying all incidental expenses to time of shipment. At that point the General Government took charge, and all further expenses have been met from the special appropriation for the purpose. Thus the demand upon the treasury of the Association in connection with the exhibit has been very light, being almost wholly confined to the expenses of the committees appointed by the Association to care for its interests. Without further comment, reference is made to the exhibit itself as the best report of its work which the committee can now render. But it is believed that there should be some permanent descriptive record of this exhibit, and authority is requested on behalf of the present committee to file a general report on the exhibit with the new executive committee.

The committee on the college exhibit has worked, as directed, in conjunction with the committee on the station exhibit and although really two divisions the result may be regarded as one joint and collective exhibit of the colleges and stations. Since the installation was completed the management has been on the basis of a single exhibit, and this has included the display of the Office of Experiment Stations of the Department of Agriculture. That office has carried, very acceptably, the greater part of the administration of the exhibit, arranging with the different institutions for the detail of college and station men who have served in turn, from month to month, as attendants, guardians, and demonstrators for the exhibit.

The attention of the Association is invited to the comprehensive and attractive exhibit made by the Government of France of the means and methods of the various branches of agricultural education in that country. This exhibit is in the Agricultural Building of the Exposition, immediately adjoining the similar American exhibits, and, as the former has not been entered for competition, it is suggested that this convention might well ask of the Exposition authorities some special examination and official recognition of this excellent French exhibit.

The Association has been represented on the committee supervising the tests of breeds of dairy cattle at the Exposition, in accordance with the action of the convention at New Orleans, and a report may be expected from the testing committee. The executive committee was charged with the duty of providing for payment of the necessary expenses of the four Association members of the testing committee, upon consultation with these gentlemen, and authority was given to call for an extra contribution to the treasury of the Association for this purpose. It has not seemed expedient to make such a special call for funds the present year, when the various institutions have been taxed in several ways on account of the Exposition. Other methods have been tried in the hope of relieving the treasury of the Association from this particular and rather large item of expense. These have failed, however, and the committee now refers the whole question back to the Association for settlement. The subject of the relations of the Association and the Exposition has accordingly been assigned for consideration and action at the general session of this convention on

Wednesday morning. It should be stated, however, that the ordinary income of the Association has enabled the payment of the expenses of the testing committee up to July 1, as well as all other obligations of the Association to date, and it is therefore recommended that arrangement be made for carrying over to the next year the remaining cost of this special committee, amounting to about \$1,000, and providing for such increased revenues then as will cancel this debt from the general treasury.

A committee was appointed, as ordered, to coöperate, on behalf of this Association, with the general committee of the World's Congress Auxiliary upon Agricultural Congresses. A statement of the duties performed may be expected from Prof. Morrow.

The chief of the department of agriculture of the Exposition was duly notified of the willingness of the Association, through its executive committee, to coöperate in arranging for a series of popular lectures on agriculture at the Exposition, but after a few trials in June, Chief Buchanan wisely concluded to abandon this project.

Your committee reports that upon investigation, as directed, it has been ascertained that Preston Powers, sculptor (son of the famous Hiram Powers), has, at his studio in Florence, Italy, an original model, or mold, of a bust of Hon. Justin S. Morrill, taken about the time of the passage of the first land-grant college, or Morrill, Act (1862). A plaster cast from this model is now to be seen at the central space of the collective college exhibit. Mr. Powers offers to make a new marble bust from this mold, and from this to have twenty-five plaster casts made, everyone to receive his personal attention and final approval, if guaranteed the sum of \$800. If a larger number were ordered, the price of each bust could be materially reduced. Forty could be obtained at about \$25 each. In any case the marble would become the property of the subscribers for the casts, and it is suggested that this might be deposited, in the name of the Association, at some suitable place in Washington and that other casts might be made from it subsequently. It should be understood that the casts proposed to be made by Mr. Powers represent an article much superior in quality and finish to the ordinary plaster casts for museum purposes.

In accordance with the instructions of the New Orleans convention, a subcommittee of the executive committee met the President-elect of the United States by appointment in New York in the month of February last. The condition and work of the colleges and stations in the several States were presented, and their relations to the General Government were discussed. The scientific work of the Department of Agriculture was also considered. Subsequently the same committee had a similar interview at Washington with the newly-appointed Secretary of Agriculture. The President and Secretary both expressed themselves as fully appreciating the work of the colleges and stations and as desirous of coöperating in the promotion of the welfare of these institutions and of the interests by them represented.

It was found impracticable to secure the attention of the new Secretary of the Interior to the matter of the several reports required from college officers before the close of the last fiscal year. Since that time the period of college vacations and the opening of the new academic year have combined, with other things, to prevent the desired conference on this subject. Your committee reports this as the one duty committed to it by the last convention which has not yet received attention, but suggests that time still remains for this work to be done before the next annual reports become due.

The Association at its last convention appointed a special committee to consider and report upon a system for uniform station publications. This committee duly reported through its chairman, A. W. Harris, and the report is submitted herewith. It was at first intended to publish and distribute this report soon after its completion, but it was finally decided to postpone such action until after the distractions of the Exposition year. It is now recommended that this report be referred to the new executive committee for publication and distribution, and that it be also incorporated in the proceedings of this convention.

Another special committee was appointed at New Orleans upon college statistics,

with instructions to report to the convention of 1893, and President Atherton, as chairman of the committee, is prepared to comply.

Since the last annual meeting the executive committee has issued twelve circulars of information, most of them in connection with Exposition matters. These have been distributed to all institutions eligible to membership under the constitution of the Association, as revised. Now that this constitution has been printed, it is recommended that every institution eligible to membership be furnished a copy, with attention called to conditions of membership, and be served with notice that hereafter no institution will be recognized as entitled to share in the work and benefits of the Association unless it be a member thereof in full standing.

The annual contribution of \$10, agreed upon at the last convention, has been very generally paid and has proved sufficient, together with last year's balance, for the needs of the Association to date, excepting, as already noted, the expenses of the dairy test committee since the 1st of July. The treasurer's report will show a balance from last year of \$416.54, with collections of \$860, making the total receipts \$1,276.54; disbursements in all amounted to \$1,266.91, leaving a balance of \$9.63 on hand at the present time. The obligations of the Association on account of its representation on the dairy test committee of the Exposition will amount to about \$1,000 at the close of the present month. It is believed that the simplest and most equitable manner of meeting this unusual expenditure is by a sufficient increase in the annual contribution asked for next year. The committee therefore recommends that the dues for the coming year be fixed at \$15 for every eligible institution, believing that this will enable the Association to free itself from debt. The executive committee should also be authorized to make special call for additional funds in case of need, although this does not appear likely. It is further suggested that some special means be taken to impress upon all interested that no matter how close the actual relation of college and station in any State, or as part of one institution, this Association regards every college and every station as a distinct and separate institution for purposes of taxation and representation.

Under existing circumstances, it has been thought unnecessary to issue any program for the present convention other than the schedule for meetings contained in the supplementary convention circular. It is now recommended that that be adopted, subject to the further pleasure of the convention, and also that the precedents of recent conventions be followed as to credentials and rules of order.

Respectfully submitted for the executive committee.

HENRY E. ALVORD,
Chairman.

CHICAGO, ILL., October 17, 1893.

Mr. HADLEY. I move that the report be accepted and that it be considered in its various recommendations seriatim at the proper time.

Seconded by Mr. Scott.

The motion was carried.

The report of the treasurer was then presented by Mr. Scovell.

REPORT OF THE TREASURER OF THE ASSOCIATION.

M. A. Scovell, treasurer, in account with Association of American Agricultural Colleges and Experiment Stations.

Balance on hand at last meeting	\$416.54
Moneys received since last meeting—dues 1892-'93	860.00
Total.....	1,276.54
Expenditures	1,266.91
Balance on hand	9.63

REPORT OF THE TREASURER OF THE ASSOCIATION—Continued.

EXPENDITURES.

Stationery and printing.....	\$70. 90
Subcommittee to see President, etc. (expenses)	248. 11
Dairy test committee	818. 16
College and station exhibit committee (expenses).....	44. 70
Stenography.....	49. 29
Sundries.....	35. 75
Total, as above	1, 266. 91

ITEMIZED STATEMENT.

Receipts.

1893.

April 1. Ohio Experiment Station.....	\$10. 00
3. North Carolina Experiment Station.....	10. 00
3. Georgia Experiment Station.....	10. 00
3. Experiment Station, University of Tennessee.....	10. 00
3. Delaware College	10. 00
6. Maine State College.....	10. 00
6. Agricultural Experiment Station of West Virginia...	10. 00
6. University of Minnesota Experiment Station.....	10. 00
6. Kentucky Agricultural Experiment Station.....	10. 00
6. Michigan Agricultural College.....	10. 00
6. Michigan Experiment Station.....	10. 00
7. Louisiana Experiment Station.....	10. 00
7. Maryland Agricultural College.....	10. 00
7. Maryland Experiment Station.....	10. 00
8. Mississippi Agricultural College.....	10. 00
8. Mississippi Experiment Station.....	10. 00
8. Massachusetts Agricultural College.....	10. 00
8. Hatch Experiment Station.....	10. 00
8. Kentucky Agricultural and Mechanical College.....	10. 00
10. Ohio State University.....	10. 00
10. New Hampshire College of Agriculture and Mechanic Arts	10. 00
11. Vermont State Agricultural College.....	10. 00
12. Cornell University	10. 00
12. Cornell Experiment Station.....	10. 00
12. Purdue University	10. 00
12. Alabama Experiment Station.....	10. 00
12. Alabama Agricultural and Mechanical College.....	10. 00
12. Arizona Experiment Station.....	10. 00
12. Arizona Agricultural College.....	10. 00
12. University of Wisconsin.....	10. 00
15. Virginia Agricultural and Mechanical College.....	10. 00
15. Virginia Agricultural Experiment Station.....	10. 00
15. Rhode Island State Experiment Station.....	10. 00
15. Arkansas Agricultural Experiment Station	10. 00
17. Vermont Agricultural Experiment Station.....	10. 00
17. Indiana Experiment Station	10. 00
17. Delaware Agricultural Experiment Station	10. 00
17. Iowa Experiment Station.....	10. 00
20. North Carolina College of Agriculture and Mechanic Arts	10. 00
24. Sheffield Scientific School of Yale University	10. 00

REPORT OF THE TREASURER OF THE ASSOCIATION—Continued.

Receipts—Continued.

1893.

May	1. Connecticut Agricultural Experiment Station.....	\$10.00
	5. Massachusetts State Experiment Station.....	10.00
	6. Colorado Agricultural College	10.00
	6. Storrs Agricultural Experiment Station.....	10.00
	6. Nevada Experiment Station	10.00
	6. Nevada Agricultural College.....	10.00
	8. Experiment Station of University of Wisconsin.....	10.00
	8. Agricultural College of University of Idaho.....	10.00
	8. University of Minnesota.....	10.00
	8. Rhode Island College of Agriculture and Mechanic Arts.	10.00
	12. California Experiment Station	10.00
	12. New Jersey State Experiment Station	10.00
	13. Maine Experiment Station	10.00
	15. New Hampshire Experiment Station.....	10.00
	17. New Mexico Experiment Station	10.00
	17. New Mexico Agricultural and Mechanical College.....	10.00
	20. Iowa Agricultural College	10.00
	24. Kansas Experiment Station.....	10.00
	24. Kansas State Agricultural College.....	10.00
	26. Illinois Experiment Station.....	10.00
June	6. Colorado Experiment Station.....	10.00
	16. Utah Agricultural College	10.00
	16. Utah Experiment Station.....	10.00
	16. South Dakota Experiment Station.....	10.00
July	10. Wyoming Agricultural College.....	10.00
	10. Wyoming Experiment Station	10.00
	10. Nebraska Experiment Station	10.00
	13. Rutgers College.....	10.00
	14. Pennsylvania Experiment Station	10.00
Aug.	14. Texas Agricultural College	10.00
	17. Oregon Experiment Station	10.00
	18. Florida Agricultural College	10.00
	28. Louisiana State University	10.00
	28. University of Georgia.....	10.00
	29. Texas Experiment Station.....	10.00
	31. University of Tennessee.....	10.00
Sept.	1. Nebraska State University	10.00
	6. Missouri Experiment Station	10.00
	6. Missouri Agricultural and Mechanical College.....	10.00
	18. Alcorn Agricultural and Mechanical College, Mississippi.	10.00
	23. South Carolina Experiment Station	10.00
	27. University of Illinois	10.00
	29. West Virginia University	10.00
Oct.	4. Pennsylvania State College.....	10.00
	11. Hampton Normal and Agricultural Institute.....	10.00
	16. Oklahoma Experiment Station.....	10.00

On motion of Mr. Harris the report of the treasurer was referred to an auditing committee of three, appointed by the chair, consisting of Messrs. Harris, Emery, and Vanderford.

The PRESIDENT. The secretary asks me to announce that anyone who desires to see the items of expenditures may do so by calling upon him. It has been suggested that the several sections be called upon for their reports at this time. As chairman of the Section of Agriculture and Chemistry I make their report in these words. It has been considered best to drop the work on account of the Columbian Exposition.

We will next have the report of the chairman of the Section on Botany and Horticulture.

The chairman of the section, Mr. Scribner, of Tennessee, was not present, and no report of the section was presented.

Mr. Dabney, of Tennessee, chairman of the Section on College Work, submitted his report.

REPORT OF THE SECTION ON COLLEGE WORK.

As chairman of the Section on College Work it is my duty to make a report at this session, to occupy not exceeding twenty minutes in the reading. As it would be impossible to treat any large part of our college work in this brief time, we have sought some special phase of our work which seemed to need notice and might be profitably discussed within the limit fixed. In previous reports of our presidents and of the chairmen of the different sections we have had able discussions of almost every other department of our colleges, and we have, therefore, selected the military instruction and drill as a subject which may well receive our attention at this time.

As national colleges endowed with the proceeds of the sale of a portion of the national domain, we are especially charged with the general duty of educating our pupils in patriotism and the special duty of instructing the young men of the country in military science and tactics, so as to form a basis of a national guard in the hour of need. The Land-Grant Act was passed in 1862. The National Government was at that time greatly impressed with the importance of a class of young men educated in military science and having some experience in drill, who might be called upon to organize and command the volunteer armies when the nation needed their services. May the Nation never see just that need again! We never shall, but the experience of that time must be used in preparing for the future.

Later experience has shown that our States must be prepared at all times to put down mobs and riots. As our population becomes more dense and more mixed it is evident that we will have more and more use for strong State militia. Recent events in some of our States teach us that the way to keep the peace is to be well armed. It is well, therefore, that these national colleges were charged with the duty of training young men who might form a class of reserved military officers.

The act of July 2, 1862, requires, thus, that military tactics shall be included among the studies at these colleges. This is not left optional with the States or the management of the institutions, but this instruction is mandatory. The legislatures of the States may prescribe the manner in which all of the instruction at these colleges is to be given, but the "branches of learning related to agriculture and the mechanic arts" and "military tactics" must be taught. Other scientific and classic studies may be included, but there is no option about these subjects. Although we do not believe that military drill has been as well provided for as it might be, the Government has done a great deal for us by detailing officers from the Army, who will serve as instructors, and by the loan of a limited equipment.

Let us at this time inquire briefly into the instruction and practice given in military science and tactics in our colleges for the purpose of seeing what its needs are and what improvements may be made.

According to the latest organization list of agricultural colleges published by the Department of Agriculture there are 61 colleges receiving the benefits of the Land Grant, counting 2 for Massachusetts, 2 for Rhode Island, 2 for Connecticut, and 10 separate colleges or departments for colored students. As the latter are practically departments only we may include them with their State institutions. We have, thus, 51 separate State institutions under this Association. Thirty-seven of these have officers detailed from the U. S. Army to serve as professors of military science and tactics. Eleven out of these 51 Land-Grant colleges, chiefly new institutions not yet fully organized, have not as yet provided any regular military instruction. Two of them give some instruction in military science and drill, although they have no Army officers. It is probable that all of these institutions could have Army officers if they applied for them. The present law allows 85 to be detailed from the regular Army, and an unlimited number of retired officers, who must, of course, be paid salaries. An institution, however, which employs a retired officer can get the military equipment from the War Department.

We learn from the reports of these colleges and of the Inspector General of the Army that efficient work is being done in a majority of the colleges. Some show a want of appreciation of military science and drill as both educating and disciplinary subjects and a very few show a disposition to neglect or slight this department. We believe such colleges make an error. On the one hand for training men in habits of order, system, neatness, promptitude, obedience to constituted authority, and working together with their fellows the military drill is unsurpassed.

There can be no question as to our duty to the nation and our States. In a majority of the States these are the only military colleges. We beg such institutions to consider this instruction and practice more seriously.

According to the report of the Commissioner of Education there were, in 1889-'90, 9,433 students in attendance upon these colleges. Of this number 3,000 were in preparatory departments and 700 were women. As a rule all the preparatory students are required to take military drill, but many advanced and graduate students are excused from it. We estimate that there were still at least 8,000 young men in the military departments in these various colleges in 1889-'90. Ten thousand would be a moderate estimate for the number in 1892-'93—a small army in itself.

The gentlemen here present are all familiar with the details of instruction and practice in the military departments of these institutions. I will not, therefore, go into this subject at any length. It is interesting, however, to note the extremes, especially in regard to the time allowed and the number of classes required to take the work.

We have among our agricultural colleges illustrations of almost all forms of military government, organization, and instruction. Many of these institutions started out with military departments modeled as closely as possible after that at West Point. The older colleges, having a single course of study, with few electives, and located in the country where all of their students lived in dormitories, found that organization entirely practicable. It was especially useful so long as their student body contained many preparatory students and boys. Our country boy made an admirable cadet and profited much by this discipline and instruction. Other institutions located in towns, without or with only limited dormitories, and having, therefore, to put their students in private families, attempted the same plan, but they have, we believe, without exception, abandoned it. In these cases the Army officer was commandant of cadets and in charge of the discipline, as well as professor of military science and tactics. He was the autocrat of the college and controlled everything, including, in some cases, the other professors and their departments.

The other extreme is the large university having many older and more advanced students and many different courses and classes. In such institutions military instruction is usually confined to one or two classes and to its own hours, as the

other instruction is. Military government has been wholly abandoned in such cases, and the military professor has no more authority than any other. As our colleges developed and multiplied courses, and especially as the demand grew for work in laboratories, shops, and on farms, the organization of the military departments has been steadily modified in the direction of the latter system.

Older students find continued military drill very irksome. They consider it a hardship to have to give so large a portion of their time to it, when they have no intention of becoming professional soldiers. The juniors and seniors in our college courses taking either literary, scientific, engineering, or agricultural work are in these days completely overloaded with library, seminary, laboratory, and other practical work, and have little time for practical military work. The best of them may be induced to volunteer for this work, as is the custom in many of our colleges, by making military work an elective in science, and giving full credit for it; but it is still a problem in such institutions how to get the very best men for officers.

As all of our colleges must come to this standard sooner or later, the question for us to consider is: How shall we do our duty to the nation in respect to the training of young men in military science and tactics without interfering too seriously with the other work that we are required to do? In other words, how shall we train the citizen soldiery that the country needs and still give all of our students the "liberal and practical education" which is the chief object of these colleges?

The rules prescribed by the President for the government of officers of the Army detailed as professors of military science and tactics are contained in General Orders No. 26, 1891. They require that "the course of instruction shall be both practical and theoretical, and shall be so arranged as to occupy at least one hour per week for theoretical instruction, and at least two hours per week for practical instruction." From an examination of the reports of the various institutions I gather that the average time given to military instruction and practice is greater than this. It is probably nearer four hours per week than three.

It is left to each institution to decide what classes of students are subject to this theoretical and practical instruction. This is the main point of variation between our colleges and the most important one to be guarded. On the one hand, if the students are not required to drill in sufficient numbers and for a sufficient length of time, the institution will not have a respectable battalion, and no proficiency will be attained in the art of war. On the other hand, if it is continued too long, it becomes irksome to the student and detracts from his success in other studies. The majority of our larger institutions have, we believe, reached a proper compromise by requiring all male members of their colleges below the junior class, or third year (counting from the beginning), to take military drill, and by requiring the second-year men and all commissioned officers to receive theoretical instruction. The members of the junior and senior classes and of other departments of the university may volunteer for not less than one term of service at a time, and are encouraged to do this, whenever they have military experience, by giving them commissions as officers and credits for this work on the college course. The course of military instruction and drill should, in all cases, be a part of the regular college course and be duly credited to the student as other recitation or practical work is.

Under this plan the student is subject to drill at the period when he needs it most and can best spare the time. It is also found to be the period when he can learn it most rapidly. The boy who has had military drill for two years and acquired no special interest in it is only an obstruction in his company afterward if he is compelled to drill. If not fit for an officer after two years of drill, he had better be dropped from military instruction, as he will never make an enthusiastic soldier. This plan gives the military department the best material for privates and also the best material for officers, while at the same time it gives the college the full time of all advanced men, not specially interested in military matters, for literary or scientific work.

The original act (section 1225 of the Revised Statutes) provides that the Secretary of War may issue "at his discretion and under proper regulations to be prescribed by him, out of ordnance and ordnance stores belonging to the Government and which can be spared for that purpose, such a number of the same as may appear to be required for military instruction and practice by the students of any college or university, under the provisions of this section; and the Secretary shall require a bond in each case in double the value of the property," etc.

It is right that the property of the Government should be properly cared and accounted for, but in this whole matter of securing and accounting for military equipment and supplies these institutions and their officers are treated as if they were aliens to the Government, instead of a part of it. They are required to pay the freight on all equipment and supplies, to insure the Government property at the valuation placed upon it by the War Department (which is considerably more than its actual value), to pay the cost of all repairs, to pay for gun racks and other necessary armory furniture, to pay for all damaged and missing stores, and after they are worn out to return the débris to a national arsenal "without expense to the United States."

If we are a part of the nation and doing the nation's work, we fail to see the fairness of all this. Why should not these departments be recognized as army posts and be supplied with equipment under the same conditions as other army posts? The Government has its own officer in charge and can hold him responsible for these things under its rules. It would seem to us much fairer and certainly much simpler if the officer in charge of the instruction at each institution could make his requisition for what he wanted, have it supplied, and account for it, or return it at the Government's expense. Why should these institutions be required to pay the freight upon and repair Government property when they are using it for Government purposes? By a strange misunderstanding, this legislation, which treats us as national institutions in most matters, changes its spirit entirely as soon as it comes to this matter of military property. Is there any reason for this? We have been able to find none and must attribute it either to misunderstanding or to "red tape." If the War Department could only treat these institutions as army posts in charge of their own officers, the method of supplying equipment, etc., could, we believe, easily be modified as we suggest and in full accordance with their rules.

The Government does not supply nearly all the military equipment required. Some provision should be made for supplying uniforms, gun racks and armory furniture, side arms, band instruments, flags, tentage, and especially for the care and repair of the Government's property.

In this connection I wish to call especial attention to the recommendation contained in the report of the Inspector General of the Army for the year 1892. The Inspector General recognizes the national character of these institutions and the importance of the work they are doing in training officers for any great emergency, and favors, if we understand correctly, a more intimate relation between these colleges and the War Department. He recommends, therefore, that the Government supply all of the equipment for them, including uniforms. He says (p. 13):

"The objects of the law, therefore, are manifestly national in their character, and while the student and the college derive some benefit from the instruction received, it should not be forgotten that the time devoted to such instruction is necessarily taken away from the time which would be ordinarily given to other college pursuits, and therefore must be regarded by the student as more or less a sacrifice. Indeed, there are those who consider it a great hardship, which they seek by every conceivable excuse to avoid. It would seem, therefore, no more than right to relieve them from the special expense of preparation for military service under the U. S. Government. It should be made easy and desirable for the youth of the country to train themselves for the national defense.

"In many of the institutions where military instruction is now given, the difficulty of procuring the necessary uniforms and camp and garrison equipage is so great as to almost preclude it, and in all cases, owing to lack of experience, such articles can only be obtained at higher prices comparatively than those paid by the U. S. Government, which buys in large quantities under an efficient system of supply."

The Inspector General then refers to a joint resolution which was introduced in the last Congress authorizing the Secretary of War to supply these colleges with additional equipment, and concludes:

"I therefore earnestly recommend such legislation as will enable the Secretary of War to sell to military colleges such articles as it is legal and practicable to furnish with the means now at our disposal, and that hereafter, or as soon as the amount can be determined, an annual appropriation be made for the purpose embraced in the joint resolution, to be expended by the Secretary of War on such conditions and regulations as Congress may prescribe."

This recommendation certainly seems just. The majority of the students in these institutions are poor. They are, we will venture to say, as a class, the most earnest and promising, while they are the least wealthy class of students in our country. The cost of this uniform is a considerable thing to them, amounting frequently to one tenth of their whole year's expenses. This expense keeps, to our certain knowledge, some boys away from these institutions who would otherwise attend them. They buy the uniform simply to conform to the requirements and not for their own benefit. Under the system here proposed these students have very little, if any, use for their uniforms, as they do not wear them except on drill. Why should they be compelled to buy them any more than they are to buy their guns?

The Government appropriates \$1,000,000 a year to the different States for the equipment of their militia. Why would it not be right, then, for it to appropriate a much smaller amount for the complete equipment of these cadet battalions? Is not the educated young man who takes a two years' course of training and makes an officer of this militia in time of war entitled to as much aid as the private in this same militia who, perhaps, only serves a few months? Experience everywhere goes to show that these Land-Grant and other civilian colleges are training the men who will defend the nation in the time of need. The Inspector General cites an instance in his report above referred to of one of the oldest colleges whose military department is said to have furnished from its alumni 12 general officers, 25 colonels, 40 field officers, and 198 company officers, a total of 275 commissioned officers for the civil war. During the recent "miners'" war in Tennessee we noted that nearly all of the commissioned officers in the State militia, many of whose companies were organized for the occasion, were the graduates of our Tennessee University. We have no doubt that every State institution can submit similar facts in support of this view.

Our great, rich country should not consider the expense of this business, if it is right to do it; but if we suppose that the additional equipment of each cadet can be made and delivered at the institution by the Government at a cost of \$20 (which is more than the average cost of our uniforms, we presume), it will only cost the Government \$240,000 to equip this entire army of 12,000 boys. One fourth of the amount apportioned among the States on account of the equipment of the militia would equip all of our present battalions handsomely.

On motion of Mr. Fairchild, the report of the chairman was referred to the Section on College Work for consideration.

The chairman of the Section on Entomology, Mr. Bruner, of Nebraska, was absent, and no report was made by that Section.

No report by the Section on Mechanic Arts.

The PRESIDENT. At the New Orleans convention a committee was appointed on the uniformity of numbering station publications. The purposes for which this committee was appointed were very forcibly brought out at the New Orleans convention. It was there stated, what we all know, that the station publications were very un-uniform and that there was a marked lack of symmetry in their make-up. This committee was appointed to see wherein these publications might be improved. Mr. Harris was appointed chairman of the committee and is here ready to report. I hope that this report will be carefully listened to by members of the Association.

Mr. Harris presented the following report:

REPORT ON UNIFORMITY OF STATION PUBLICATIONS.

The convention of the Association of American Agricultural Colleges and Experiment Stations, held at New Orleans, November, 1892, after a discussion of the inconvenience arising from the different methods of naming and designating bulletins in use by the experiment stations, appointed the undersigned as a committee to devise some uniform plan to be recommended to the stations. After due deliberation and consultation, we have the honor to present the following recommendations:

The publications of the experiment stations should consist of annual reports, bulletins, and circulars.

Annual reports should be numbered in regular order, and be designated by the year which they cover, as "First Annual Report, 1888," "Second Annual Report, 1889." The annual reports should be printed as separate publications, and should not be called bulletins or numbered as such.

All bulletins, with the possible exception of meteorological bulletins, should be included in one series, and should bear the natural numbers in regular order, preferably without volume or year numbers, but in connection with these, if necessary. They should always bear the date of publication on the title-page. This recommendation involves the abandonment of the use of letters or other peculiar means to designate "special" bulletins, or those which are not to be distributed to the whole list. In case bulletins are issued for limited circulation, a note should be included in the next bulletin for general distribution, stating the character of the omitted bulletin, and explaining why it was not sent to the whole mailing list. The words "new series," "second series," etc., should be omitted from the title-page of bulletins. They are not necessary, since the number of a bulletin with the date of issue will always be sufficient for identification.

Reports of meteorological data, issued very frequently, may constitute a separate series of bulletins, if desired, but the existence of this series should be explained in other bulletins by a note.

It will add to the convenience of those who use the reports and bulletins if the stations will use page headings, printing on the left pages the name of the station ("Illinois Experiment Station"), or the designation and year of the publication ("Second Annual Report, 1890"; Bulletin 27, 1891), or both ("Connecticut Experiment Station, Second Annual Report, 1890"); and on the right pages the subject treated ("Spraying of Fruit Trees"; "Fermentation of Tobacco").

Circulars should be used for inquiries or the publication of matter not requiring permanent record, and should never be made the sole repositories of matter of scientific or permanent value.

Newspaper bulletins should never be made the sole repositories of any information of permanent value.

The committee would call especial attention to remarks of Prof. S. W. Johnson on the preparation of bulletins and reports, which will appear in the proceedings of the New Orleans convention, and to the following resolution adopted at the Knoxville convention:

“(a) The bulletins to be uniform in size, 5½ by 9 inches, and ~~not to deviate~~ from this measurement more than one quarter of an inch when trimmed. (b) The title-page to bear conspicuously the number of the bulletin, its date, the name and post-office address of the station, the subject presented, and very little besides. (c) The reverse of the title-page (or page 2) to carry upon it all other information desired to be conveyed by the bulletin, ~~except~~ its principal subject matter. (d) The annual report to be of the same size as the bulletins, if practicable.”

Respectfully submitted.

A. W. HARRIS,
W. A. HENRY,
A. A. JOHNSON,
S. W. JOHNSON,
R. J. REDDING,
Committee.

Mr. ALVORD. By direction of the executive committee I now move that this report be accepted, adopted, and referred to the new executive committee for publication and distribution, and that it also be incorporated in the proceedings of this convention.

Motion carried.

The PRESIDENT. Before the close of the session this morning it is suggested that we hear from Dr. True, of the Office of Experiment Stations, in regard to some matters of general interest to the stations concerning their relations to the Department of Agriculture at Washington. I have the pleasure of introducing Dr. True.

Mr. TRUE. In view of the new relations which I have been called upon to sustain towards the Office of Experiment Stations I have desired to come in this way before the Association that I might look into the faces of the delegates and that I might say a few words regarding the work of the Office. While I have been connected with the Office from its organization my duties, as very many of you know, have been of such a character that I have had few opportunities of getting acquainted with those actually engaged in the work at the different colleges and stations. I, therefore, greatly prize this opportunity of standing before you and it will be an inspiration to me in my work.

The Office of Experiment Stations has now been in operation about five years, and its lines of work have developed as circumstances seemed to require. The chief aim has been to do that which would be of most service to the stations and most helpful to the cause in general. At the outset comparatively little was known regarding the needs of such work, and it has only been as we have come to understand what the needs of the stations really are that we have been able to put our

NOTE.—Stations in the following named States are still using peculiar and undesirable means of naming and numbering publications: Alabama, Georgia, Louisiana, Maine, Maryland, North Carolina, Ohio, South Carolina, Tennessee, Virginia, and West Virginia.

work into definite form. It may be of interest to some of our visitors to know that the Office of Experiment Stations bears a twofold relation to the work of the experiment stations of this country. It is in the first place a branch of the Department of Agriculture, and a considerable portion of its work grows out of the peculiar relations which it sustains to that Department. For example, as a branch of the Department the Office of Experiment Stations must take its share of the daily mail that comes to the Department from all parts of the world, and, as it is one of our duties to collect information from the fifty or more experiment stations of this country which are making investigations on a great variety of problems, the general correspondence of the Office is very large and covers a wide range of subjects. We have other duties growing out of our relations to other divisions of the Department, and our work in general must be carried on under the conditions which exist in the Government service. This is true, for example, in regard to our publications, which must be issued through the Government Printing Office in regular order. We can not simply get up a publication and take the manuscript under our arm and walk into a printing office and make a bargain with the printer to get it out in twenty-four hours or a week, but the publication must go through the regular routine of the Department service.

The other side of our work, and the one to which I wish to call especial attention at this time, grows out of our relations to the colleges and stations. We take the reports of the investigations of the different stations and work them up in a condensed form for the use of other station workers; or we put certain portions of these reports into popular form for general distribution, so that people throughout the country may get information as to what is being done in the different States. Thus far the Office has expended its energies very largely in publishing documents which are primarily of interest to station workers and others engaged in investigations in agricultural science. Our principal publication, as most of you know, is the Experiment Station Record, which is issued monthly, and contains abstracts of station publications and of publications issued by similar institutions in foreign countries.

In another way we have tried to sum up the work of the stations and put it into the brief form of a card index. This enterprise is in some respects of a kind that has never before been undertaken, and we have met with unexpected difficulties, especially in the way of the publication of this work. The classification of the subjects with which agricultural science deals has never been undertaken before in the thorough way in which the Office has undertaken it. We think from what experience we have already had that we have made a reasonably good classification, and we hope that this index, which in manuscript form now covers all the past work of American stations, will be issued more rapidly, and that soon at least one copy will be found in every college

and station library throughout the country, so that those who are interested in such studies may readily find the information they desire.

As some of you may know, Congress at its last session gave us authority to sell copies of this index at a cost to cover the additional expense involved in the preparation of the copies sold. The cards will be furnished at the rate of \$2 per 1,000, and in addition to this there will be a charge of \$1.25 for a set of division cards and blocks. We have issued now about 3,000 cards, so that the cost of a set of the index up to date will be \$7.25.

In this informal talk concerning the Office I will mention one other feature of our work in a direction in which we hope hereafter to make greater development. We have been at work for some time in getting up a collection of station publications from the earliest ones down, and we believe that we now have as complete a set as there is in the country. This, as far as possible, we desire to make available to those who have no such collection, and beyond that we want to do a great deal more in the direction of library and bibliographical work. To that end we have secured recently the appointment of a man who will give his attention very largely to that work. The aim will be as far as possible to get acquainted with the literature of agricultural science, and especially with the earlier publications; to know where they are, whether in the library of the Department of Agriculture, the libraries of the different institutions, the Library of Congress at Washington, or elsewhere in the country; to know how they were published, where they may be obtained if still for sale, or how they may be loaned to those who desire to use them, so that the workers in our stations and colleges who desire to study up the literature on any one subject may go beyond the resources of their own libraries and have as far as possible at their command the resources of the libraries of this country which contain works on that subject. Of course this work will require a great deal of labor and can only be gradually performed.

In conclusion, I am glad to say that the prospect is that we will be able, without hindrance, to carry on and develop our work so as to make it more useful to the stations and colleges, and I trust that the same spirit which has pervaded the work of the Office in the past—I speak freely of this because I have had no responsibility for it—will be continued. We shall look with confidence for your coöperation and aid in the formulating and carrying out of plans by which we can make the Office of Experiment Stations more truly helpful to the great cause in which we are all so much interested.

I thank you for your kind attention to these informal remarks, for I had no thought of speaking just at this time, and had prepared no notes.

Mr. ALVORD. I think it desirable that as much business as possible be accomplished to-day, and as I understand from the chairman of the

coöperative station exhibit that he is willing to present his report to-day, I suggest that he be requested to do so at this time.

Mr. ARMSBY. The committee on the coöperative station exhibit desires to submit to the executive committee a more full and complete report than it has been possible as yet to prepare. We therefore ask leave to present at this time a mere preliminary report and be permitted to file a more complete report with the new executive committee.

The PRESIDENT. I am sure that permission is granted. Proceed.

REPORT ON THE COLLECTIVE STATION EXHIBIT.

Your committee having made two previous reports of progress in which the nature and purpose of the collective station exhibit were described in detail, begs to submit, as the most essential part of its final report, the exhibit itself, located at column D, sec. L-3, in the Agricultural building.

While aware of its defects and conscious that we have by no means reached our ideal, we recognize that the exhibit is the ultimate measure of our success or failure, and we therefore submit it to the indulgent judgment of the Association without apology on the one hand or laudation on the other.

We desire to gratefully acknowledge: First, the very cordial support and coöperation of the several stations. Out of the 54 stations of the United States, 47 are represented in the exhibit, many of them by contributions which have cost much time, labor, and money. Nearly all those stations which did not contribute expressed an interest in the exhibit and regretted the circumstances which seemed to render it inexpedient or impossible for them to take part.

Second, we desire to acknowledge and to call the attention of the Association to the faithful services of those gentlemen who, at no little personal inconvenience and for no reward except the promotion of the general welfare, superintended the collection and installation of the several subdivisions of the exhibit.

Third, we feel that very special and grateful recognition is due the U. S. Department of Agriculture and its representatives, the Hon. Edwin Willits, Assistant Secretary, and Mr. A. W. Harris, Director of the Office of Experiment Stations, both for the very generous financial support, without which the undertaking would have been impossible, and for their personal interest and labors in its behalf. The installation of the exhibit, as well as its care, has been, in accordance with the original understanding, entirely under the charge of the Department and specifically of the Office of Experiment Stations. Your committee endeavored to render such aid as lay in its power, but the whole burden of responsibility and annoyance, inseparable from the installation of so large and complex an exhibit under the conditions prevailing during the early days of the Exposition, rested upon Mr. Harris and his assistants.

Fourth, we wish to record our appreciation of the hearty interest taken in the exhibit by the Hon. W. I. Buchanan, Chief of the Department of Agriculture of the Exposition, as shown in the generous assignment of space in the Agricultural Building and the many courtesies extended to the committee.

Respectfully submitted.

H. P. ARMSBY,
Chairman of Committee.

The PRESIDENT. Unless objection is made the committee will be continued.

Mr. ALVORD. Mr. President, I would remind the Association that the general exhibit of colleges and stations has been made in coöperation

with the Department of Agriculture, and it seems to me well to have this connection maintained. I think, therefore, it would be well to hear from the Director of the Office of Experiment Stations as to whether reports on the laboratories can be made and filed with other reports, and published with them in the proceedings of the Association.

Mr. TRUE. I think that without doubt it will be feasible for the Office of Experiment Stations to prepare such a report and have it form a part of the proceedings of the Association.

[It has not been practicable to include the detailed report of the exhibit of colleges and stations in the present bulletin, but arrangements will be made for its publication later.—EDITORS.]

The PRESIDENT. The Bureau of Education of the Department of the Interior is represented here by Mr. J. W. Holcombe. We should be glad to hear from Mr. Holcombe regarding the relations of the Department of the Interior to the agricultural colleges.

Mr. HOLCOMBE. Mr. President and members of the Association: A year ago at this time I had the pleasure of being present at a convention of this Association at New Orleans as a visitor, representing informally the Secretary of the Interior and the Commissioner of Education. At that time it seemed good to the Association to provide that the Interior Department, through the Bureau of Education, should be regularly represented by a delegate, and it is my great pleasure to be present here to-day as a delegate for the first time from the Department of the Interior, and to express to the Association the appreciation of the Commissioner of Education and the Secretary of the Interior of your action at that time.

The relations of the Department of the Interior with this body came about through the act of Congress generally known as the Second Morrill Act, providing additional endowment for the agricultural colleges. The Secretary of the Interior was made by the law the administrator of that act, and by a departmental order this duty is assigned to the Bureau of Education. It may be interesting to the Association to know that all the States and Territories of this Union are now recipients of the benefits arising under this Second Morrill Act, except the Territory of Alaska, the Indian Territory, and the District of Columbia, and it is assumed that these political divisions are not entitled to its benefits without further legislation; at any rate, they have no institutions entitling them to any of this fund. The State of Montana has organized a college of agriculture and mechanic arts and received one installment last year, the year ending June 30, 1893, and that State, together with all the others, received the appropriation, at the beginning of the present fiscal year. I had the honor at the New Orleans convention to speak more formally about the reports of treasurers and presidents of colleges made through the Bureau of Education to the Secretaries of the Interior and Agriculture. You will remember that the act

requires that reports of treasurers shall be submitted on or before September 1. This requirement has in most cases been complied with, a very few reports coming in after September 1. I refer now to the present year, September just passed, because previous to this time, owing to the inevitable delay in putting the law into effect and the difficulty, I suppose, of the different colleges preparing themselves to receive the fund, this requirement was not looked into very closely. But the language of the law seems to be mandatory that the treasurer's report should be submitted before September 1, and I take the liberty of calling attention to this, though it has not seemed necessary to the Commissioner of Education to notice that point up to this time; yet there is no telling how a requirement of that kind will be interpreted hereafter.

No date is mentioned in the law for the rendering of reports of presidents, and consequently the Commissioner has recommended the States and Territories to receive installments of the appropriation without regard to these reports, basing his action on the report of the treasurer. But I beg leave to say on the part of the Bureau of Education that it would greatly facilitate the work of the Bureau in tabulating general as well as financial statistics of the different institutions, to make a full and satisfactory comparative showing, if the presidents' reports could also be had before September 1 or very soon thereafter. Each bureau of the Department of the Interior makes an annual report of its work to the Secretary on September 1. The receipt of these reports at that date would afford the Commissioner of Education an opportunity to present at a very early date the work of these colleges for the year just closed. We could at that time make a complete tabular statement of the financial and general educational statistics of the institutions which could be distributed to all these institutions and to some extent among the educational officials of the country.

I thank you for your kind attention, and am very glad to be present in the Association again.

The PRESIDENT. Is there further business?

Mr. ALVORD. I would suggest that as to-morrow's meeting will probably be the last in general session, any resolutions which are to be offered should be submitted now in order to be acted upon by the executive committee.

Mr. TRUE. In the report of the executive committee attention is called to the exhibit of French agricultural schools and experiment stations. I think that there should be some expression of appreciation of this exhibit on the part of the Association, and therefore move that a special committee be appointed by the chair to consider what ought to be done in this and all similar cases, and report to the Association later.

The motion was carried.

Mr. KELLOGG. In conformity with the suggestion made in regard to the meeting to-morrow, I would like to present a resolution in regard to the method pursued by the Government in the distribution of seed.

Resolved, That it is the sense of this convention that the distribution of plants and seeds should be put into the hands of the agricultural colleges of the States and Territories.

This resolution was, under the rules, referred to the executive committee.

Mr. FAIRCHILD. I would like to offer a suggestion as to station notes given in the Experiment Station Record. It seems to me that the stations doing the least make the most reports, for the reason, I suppose, that they have plenty of time for it. Is it not possible to make the form of request for information more explicit, to so formulate it that every station will have to report certain data each month, showing what is going on at the station? As it is now it is a matter of judgment whether anything is worth reporting when compared with the many things undertaken. It seems to me that the Experiment Station Record would be worth more if there was a report of progress from each station.

Mr. TRUE. The Office of Experiment Stations desires to publish in the Record any item of news which is of interest to college and station workers, and would be glad to receive news from any and all college and station officers.

Mr. WELBORN. I submit the following resolution:

Resolved, That it is the sense of this Association that Congress should provide uniforms and other military equipment for the cadets at the Agricultural colleges.

Mr. DABNEY. I suggest that this resolution be referred to the Section on College Work, which has this subject under consideration.

The PRESIDENT. Unless there is objection the resolution will be so referred.

Mr. MORROW. I wish to call attention to the fact that the evening session will probably be held in the hall adjacent. It is to be, formally, a joint session of this Association and the Section on Agricultural Education and Experiment. President Henry will deliver his annual address and we confidently expect that Sir Henry Gilbert, of the Rothamsted Experiment Station, will arrive during the afternoon and will be here to deliver his address. President Fairchild, of Kansas, will deliver an address on intellectual development in agricultural education.

On page 33 of the general program of the Agricultural Congress you will find the one of interest to this Association. I wish to call especial attention to the program for Friday afternoon, which will be devoted to agricultural features of the Exposition, more especially the dairy test. Papers will be presented by Profs. Armsby, Roberts, and Scovell. Dr. Babcock will give the history of the methods of work and some of the results, and Prof. Farrington the laboratory features, of the test.

Chief Buchanan will present a paper on the agricultural features of the Exposition in general.

I may state that after consulting with the authorities, I am able to announce unofficially that the Section on Education and Experiment of the World's Agricultural Congress will meet to-morrow afternoon at 2 o'clock, instead of at 10, as stated in the program, and thus avoid conflict with the program of this Association.

The meeting adjourned at 12:30 p. m.

AFTERNOON SESSION, TUESDAY, OCTOBER 17.

The joint session of the Association with the Section on Agricultural Education and Experiment of the World's Agricultural Congress was called to order by Chairman Morrow at 2:10 p. m.

The following papers were presented:

Agricultural Education in France, Leon Vassilliere, agricultural commissioner from France.

Agricultural Education in Russia, Peter R. Slieskin, professor in Agricultural Academy, Moscow, Russia.

The Agricultural Societies and other Agricultural Forces of Belgium, Paul DeVuyst, agricultural inspector, Belgium.

The Relations of the General Government to Agricultural Experiment Stations, A. W. Harris, president Maine State College, late director Office of Experiment Stations, U. S. Department of Agriculture.

Agricultural Education in Germany, Dr. A. Backhaus, Berlin.

Agricultural Education in Japan, T. Menami, professor of agriculture, Imperial College of Agriculture, Japan.

EVENING SESSION, TUESDAY, OCTOBER 17, 1893.

The meeting was called to order by Chairman Morrow of the Section on Agricultural Education and Experiment of the Agricultural Congress.

President W. A. Henry was introduced and delivered his annual address.

PRESIDENT'S ADDRESS.

In previous gatherings of this Association your presiding officer, always having been chosen from the college side of the organization, has naturally dwelt largely on the educational features of our work. Representing the station side more particularly, it seems eminently proper that on this occasion I should direct your attention to matters which relate to experiment stations, their organization and work.

The gift of the General Government to each of the several States of the Union of \$15,000 annually for agricultural investigation stands without a parallel in any other country in its liberality toward agriculture, and is surpassed in this only by that other gift to agriculture whereby in one act there was ceded to the several States some 11,000,000 acres of land for founding agricultural and mechanical colleges. When the history of our American experiment stations is written, it will be found that the relations of our stations and agricultural colleges are so intimately interwoven that an account of the one will be incomplete without the history of the other.

When the grant of 1862 was made, there was little besides theory in regard to agricultural education in this country, and from the president of the board of trustees down to the lowest instructor there seemed to have been only the crudest ideas

in relation to the proper method of procedure. As in every case where there is no clear conception of the work in hand in advance of its inception, many mistakes were made in the organization of these institutions, some serious, yet in a majority of cases all will work out well. As I review the situation it seems to me that our experiment stations have made fewer mistakes, and as a consequence have attained far greater success in the short period of their history than did our agricultural colleges in a like length of time. And the explanation of this is easily within our finding. Our colleges, originating in the act of 1862, had but a single example of an agricultural college in this country, and but little was known of those in the old world. With our experiment stations the case was quite different. Some of the German stations had been in existence for a generation, and had accomplished much for the development of agricultural science. Then there was Rothamsted, that ideal station, the work of which is more or less known and appreciated by every intelligent American farmer, and whose reports are regarded by all investigators and teachers in science as agricultural classics. This station had been working for forty years, and its light had shone clear round the world. In our own country the Department of Agriculture at Washington, in some of its divisions, had been conducting most fruitful investigations, not only greatly aiding American agriculture, but, what was equally important, had been training men to this very line of work. Several of our States had already established experiment stations, and some of them were making excellent reputations. The very growth and struggles of our agricultural colleges had accomplished much toward breaking the way for our stations.

In some fair measure, then, times were ripe for the coming of the stations; still, as I look back, it seems to me the act was too general, and too sudden for the greatest good to be derived from the expenditure. The report of the Secretary of Agriculture for 1892 shows that there are now nearly 500 workers in our various stations. In calling to this work in a single year hundreds of men it was impossible that all should be properly trained for the work, and many of those selected were not fitted for it either by training or by natural adaptation, and as a consequence there has been much shifting and replacing, the end of which I fear is even yet not reached. I believe it would have been far better for the reputation of both our agricultural colleges and our experiment stations had the acts establishing them contemplated a progressive gradual movement. This might have been accomplished by coupling conditions with the grant making it obligatory, for example, that each State, in order to receive Government aid, must show its earnest by placing a liberal sum with that given by the Government. This would not only have insured a larger income to the institutions when established, but would have caused each State to regard the matter seriously before taking the initial step. In consequence, probably but a portion would have availed themselves of the act at first, and, this true, these pioneer colleges and stations would have proved the training ground for teachers and investigators for those institutions organized at later periods.

It is now about six years since the passage of the Hatch Act, yet in that brief space of time more than forty stations have been organized and, with all the mistakes, many now have on record investigations creditable to scientific effort and the cause they represent and a few have made a marked success. If you ask me to point out some of the successful efforts of our stations, let me refer you to the great work done in regulating the manufacture and sale of commercial fertilizers in the Atlantic and Gulf States. Without the closest regulations and the protection of law, there is no material in trade where fraud is so easily perpetrated, and where deception is so difficult of detection, as with commercial fertilizers. Our experiment stations have not only done much in developing methods of analysis by which the qualities of fertilizers are made known, but they have secured the placing of laws on the statute books to regulate the guaranty and sale of fertilizers, until now more than \$30,000,000 worth of this material is annually bought by farmers in a business-like way, no purchaser being ignorant of what he is securing unless he is blind to

the facts laid before him by the stations. Then, too, the study of the effect of these fertilizers upon the growth of crops has been very helpful.

The subject of economic entomology serves another excellent illustration. The Department of Agriculture at Washington early recognized the importance of this branch and the large opportunity it presented for helping agriculture, and here and in a few of our leading colleges and stations there has grown up probably the best corps of agricultural scientific workers we can point out in this country, excepting only the agricultural chemists.

A number of our stations are spending much effort in a study of the Indian corn plant, and already great good has been wrought in the knowledge of how the nutrients are elaborated by the growing plant constantly increasing in amount until the very closing days of its life. Then, too, the work in showing the large amount of nutrients in the cornstalk, aside from the ear, has been worth untold good to our farmers, and is working a small revolution in agriculture in the corn belt.

At the South the sugar-cane investigations and the introduction of new forage plants have been of great help to the planters, who have in a most marked way shown their appreciation of what has been accomplished for them. The waste of cotton seed by the Southern planter for generations and until very recent times is perhaps the most marked example we can point out of the enormous cost of ignorance. Southern stations have shown that in the cotton seed, cotton-seed meal, and feed hundreds of thousands of cattle where there was only waste before.

The dairy industry, one of the greatest in agriculture, is now undergoing remarkable revolution, which was started by scientific men on the other side of the water, and has been caught up by our own investigators in America, and untold good has been accomplished. No line of agriculture is so rapidly being placed on a scientific basis as is dairying. In all this progress our stations hold an honored position.

Lack of time prevents my calling attention to other work accomplished, but there is one instance that I can not forego calling to your mind. So general has become the interest in agricultural investigation that our World's Fair directors, in planning this colossal exposition, could not escape the impulse, and so here, right in Jackson Park, during all the coming and going, hurrying and sight-seeing, there has been conducted the most remarkable dairy investigation ever undertaken. All honor to Chief Buchanan and the directors who stood by him in his worthy work of rounding out the great agricultural branch of the Exposition with a genuine scientific agricultural investigation! When, as members of this Association, you have come to comprehend the scope and value of the dairy test now closing, and measure its help to that great industry, you will begin to appreciate what a vote of confidence was awarded us by the directors of the Exposition when last November, at New Orleans, they asked this Association to appoint from its members experts, who, in conducting this test, should not only hold the balance of power, but be the main source of direction and control in this great experiment.

If you ask for still further evidence of appreciation, I can point you to the data in the last report of the Secretary of Agriculture, which gives the revenue of the stations for 1892. You will there note that for the support of experiment stations the General Government gave aid to the amount of \$689,000 in round numbers. The individual States supplemented this sum by the very large amount of \$152,000, while local communities added \$85,000, and individuals over \$1,000. In other words, States, local communities, and individuals gave over one third as much as the General Government in financial aid to our stations, and the proportion given by the States is rapidly increasing. Surely there must be some appreciation of the work we are doing to have called forth such generous aid from those who, best of all, are in position to measure what we are accomplishing.

One reason that every earnest, faithful, working experiment station has a strong hold on the agricultural people is because its workers have met the farmers at the

institutes and farmers' club meetings for frequent conference, and have given instruction through the agricultural papers, acting in no small degree as teachers and counselors. It is true that when a station worker is on the institute platform or addressing a farmers' club, he is not investigating, and when he is writing for the agricultural press he is not doing laboratory work, but the call for help from our farmers has been so great, and so marked their appreciation, that it has been impossible to escape it. With earnestness on both sides and a desire to give and receive help, the most cordial and close relations now exist in a number of our States between the experiment stations and the intelligent farming people. To be frank with you, I believe that our station workers have in many cases accomplished more good for the cause of advanced agriculture through their efforts at instruction than through all they may have discovered.

Nor is this anything but natural when we study the subject carefully. The investigators of Europe had discovered and accumulated a large amount of material of great value to agriculture. Little of what they had done had been explained and made known to the great mass of farming people in the days before the establishment of our stations. Finding this rich material available to our people for the presentation, it is not the least surprising that our station workers have made good use of it in many ways. It is as though we had found gold mined by workers in the Old World which we could have for the asking; we have taken this gold to our American farmers, and in giving it we have not only received thanks from them, but, what is more important, we have gained their confidence in our assertion that there is much that can be discovered in agriculture that will be helpful to them.

The more I study the work of our experiment stations, the more I am pleased with what we have accomplished, and the larger grows my faith in the high position they are destined to occupy in American agriculture.

Trusting that I have left in your mind no uncertainty of my position on this point, let me turn your thoughts now to some of the errors I believe we have made in the management and direction of our stations in the pioneer days of their history, now closing. I admit our stations, one and all, have made some serious mistakes, but I believe they have been of the judgment and not of the heart.

If we study the reports and bulletins as they come to our tables, I think we must all confess that many of the so-called experiments and tests reported show marked faults. Very frequently there is apparently little careful planning and that preparation so essential to good scientific work. With the preliminary work slighted, it is not surprising that other evils follow. Often the figures given in the report are inaccurate on the very face of them, showing errors in simple addition and multiplication; sometimes the proof-reading is careless and the explanation of the work ambiguous and faulty. All of this leads to the suspicion that back of the report were slovenly methods and lack of care in keeping records.

Another error into which many of us have fallen is the lack of continuity. An interesting investigation appears in some bulletin or annual report; the author has taken up his subject in good shape and his investigations are interesting and show a profitable line of experimentation. When later reports come to us, we open them hoping to find additional work on the subject before discussed, but often it is lacking, and the investigation seems to have been dropped for some new line. I here venture the assertion that there has not been a single investigation undertaken by any one of our stations and carried on faithfully for a series of years that has not brought forth good returns for all the capital, mind, and money that has been put in it.

One reason for the lack of continuity is the numerous changes in the personnel of most of our stations. Unfortunately our workers have been shifting about, many dropping out to be replaced by new ones, while others go from one station to another, and in almost every case where a change is made, the work in progress is dropped for something new. Again, changes are frequently made by direction of

those in authority. Boards of trustees are constantly changing their membership, and each incoming member is apt to be fired with a burning zeal to distinguish his entry into office by some striking innovation. Here is an excellent opportunity for tact on the part of the director; let him begin the work of educating his board at once, and impress upon them the necessity that each one first understand the situation before advice and counsel looking to changes are given. In illustration of this let me point to a case which occurred at the Wisconsin Station. A certain new member of the board, one who is an ardent admirer of the trotting horse and horseflesh in general, was placed on the station committee. Now, for reasons which seem proper to me, we have never undertaken work with horses at our station, and I assure you that my fears were great when I was told by friends that our enthusiastic trustee would soon have a race course on our station grounds as well as a stable of fine trotters. I have no doubt but his first inspection of our live stock filled him with disgust, and he mentally resolved on some marked changes. But he was a sensible man, fearing radical changes, and willing to study the situation. The result is that for two years I have had the most cordial support from this trustee, lover of horseflesh though he still is, and to-day at our station we have not a horse that can trot a mile in less than five minutes.

But there are often more earnest and importunate advisers to the director than his trustees. There is hardly a man in this country, be he lawyer, doctor, or of any other calling, who has not a weakness for some special line in agriculture or horticulture. And so all classes of people are interested in our station work. Sometime since a lawyer in our State wrote to the president of our board stating that the influence of the moon on vegetation had never been properly studied; that it was a fact that some of those who believed in the moon theory were among the best farmers in the country, and he hoped that our board would at once direct the establishment of a line of investigation which should study this important and burning question. Only a couple of weeks since a letter came to the station from an intelligent citizen saying that he had as yet found nothing in our reports regarding mushroom culture, a subject in which he was deeply interested, and that he hoped to see the Wisconsin Station soon a leader in this work. Not only have we many counselors and advisers from outside our stations, but there is no lack of this form of assistance from within. Many of our workers are young men, with fertile brains and an eagerness to drop the old and take up the new, rather than plod on year after year in some treadmill line. If we are to do better work in the future we must not only work more carefully and more thoroughly, but we must more completely carry out each line that is undertaken before beginning anything new.

If the suggestions just made are to be carried out generally, we must cut down the lines of work we are endeavoring to carry, for many of us are attempting to cover too large a field with the force and means at our command. There must be a greater division of labor among our several stations, and each must be content to leave to others certain lines of investigation, much as we should like to carry them on ourselves. To show that I am trying to follow in some fair measure what I am advocating, let me call your attention to what some of you have noted, perhaps with surprise, as you have looked over the list of our station workers. At the Wisconsin Station we have neither botanist, entomologist, nor veterinarian at this time. When laying out the work it seemed to me that economic entomology was already quite well cared for by the excellent corps of workers in the Department of Agriculture at Washington and the men of marked ability in several of our stations. In order to put our work in entomology equally creditable with the best of other stations, there must be an outlay of several thousand dollars a year, and I believed that we had better use this money in some other line and let the farmers and horticulturists of Wisconsin get their information regarding insects and insecticides from these other sources. By thus saving and concentrating we now have at our station four employés who give almost the whole of their time to the single line of

dairy investigation. I believe we are a stronger station by having four men in the single line of dairying than had we four working in four different fields. State lines count for but little in this country. The Babcock milk test worked out in Wisconsin is as helpful to an Iowa dairyman as to one living in Wisconsin. Prof. Roberts's work at Cornell on the great waste of barnyard manure through leaching in the open barnyard is as instructive to an Ohio farmer as though it were performed by his own station.

In endeavoring to strengthen our work we must allow a large sum for maintenance and equipment after providing for salaries. In looking over the reports of some of our stations I am surprised at the small amount of funds left after the salaries are paid. I do not see how the workers in such stations can be content, for surely they can not always have the proper apparatus to work with.

Another fault has been the lack of coöperation. We have talked about it in our annual gatherings, but have made little progress. I still feel that, though we have accomplished little, we should continue to look toward a more general and hearty coöperation among those stations pursuing kindred lines of investigation. Why can not those stations which are conducting experiments in dairying confer together in regard to the work in hand, and agree that some parts of it at least should run along the same lines? Why can not stations which are endeavoring to determine the effect of distance of planting on the yield of corn have some things in common in their work? And so on with many other lines. There should be no coercion, and I would have our workers drawn together in their coöperative efforts by natural affinities rather than by positive direction from this or any other body. Whether or not we work together, I have no fears of the useless duplication of work. That was talked of in the first meeting of this Association, but of late we hear nothing regarding it. If we had more duplication we might be more assured of the correctness of some of the results announced.

One more point where it seems to me our stations must improve, and I am done. Should there not be a clearer demarcation between the duties of teacher and investigator in our colleges and stations, and has not our work suffered in the past because of the poor definition which now exists? Our agricultural colleges are the older institutions, and in a generation they have developed a goodly number of able teachers; the stations coming last, and having been added to, the colleges, it has followed quite naturally that in manning them the workers were drawn largely from the teaching force. In a number of cases we find that the president of the college is director of the station, and that each of the divisions of investigation is assigned to a college professor. First of all, how can the president properly do double duty as executive officer of the college and director of the station? The successful president of a modern college represents a combination of more attainments than is required in any of the learned professions, and nowhere is there a harder-worked man. He is a diplomat in his dealings with the State officials on the one hand and no less so while daily attending to petty matters of discipline among the hundreds of pupils under his charge. He is a financier of marked ability in ever watching to increase the income of his institution from every possible source, while yet closely supervising and guarding every expenditure, no matter how small. Besides the accomplishments of diplomat, financier, and guardian of hundreds of young lives he must withal be scholarly, and with voice and pen wait the beck and call of numerous organizations throughout the State. With all this and still other duties, let me ask you, how can a man give proper attention and direction to scientific investigation? As well might some railroad magnate let his ambition carry him to the belief that he could serve as president, general manager, head counselor, and division superintendent of a great railway system.

Nor is the situation markedly better in the case of a hard-worked professor. Our colleges expect not less than three lectures or recitations daily, and often much additional instruction is placed upon them. When the station comes in for consid-

eration these authorities seem to hold that after the teacher has spent three or more hours in the stuffy class room he may just as well devote the remaining hours of daylight to refreshing himself by good, vigorous work as an investigator, since, the two lines being so different, one must prove a recreation from the duties of the other. In a spirit of generosity the authorities sometimes drop an hour a day from the work of a professor that he may have an abundance of time for his investigations, and even agree that he shall have assistants to carry out the details of the work, leaving only the planning and general supervision.

Now, it generally turns out that these assistants are recent graduates, who gladly accept the positions as stepping-stones to something better; often they are undergraduates eager to earn a few dollars to help pay their way. I believe such a combination as this is most unfortunate for the college, because it is harmful to the station which is associated with it. No man, however able, is properly prepared to do any considerable amount of class-room work and then conduct investigations of the grade that our experiment stations must call for in the future. But it is said that these men are not asked to actually do much of the work, but only supervise it. I ask you, how can high-grade investigative work be carried on through subordinates of the class usually given to teachers as helpers in such cases as this? As I understand it, investigation requires in some measure the same play of faculties as does invention; what inventor would be willing to devote his best energies each day to some other line of work, and in lieu of his own powers thus diverted, substitute the work and observation of novices? If we are to secure the highest result from our station work, our investigators must be put just as close to their subjects matter as is possible and they must stay there from first to last. The investigator who is experimenting with steers or swine must keep close to his animals every day of the trial, not a mere looker-on, but a most careful observer and recorder of every action and every development. He who has growing plants under his charge must stay close with them from the time the seed is put into the ground until the harvest is over and the analyses completed. The teacher who spends his time in the class room or at his desk and turns over the care of his animals or his growing crops to subordinates is sure to lose that living connection which must hold between worker and the objects investigated if there is to be any real scientific advancement. You might equally well have come to this great Columbian Exposition by proxy. You could readily have secured a young man for a dollar or two a day and expenses who would come here and tramp through these buildings faithfully week after week and send to you a carefully written record of his observations. But you would not have seen the Fair, nor can any man who wishes to get down to the marrow of an experiment do so by any other means than by giving himself up to that experiment, soul and body, from start to finish. But it will be said in extenuation of the system that our teachers are brainy men and have lots of work in them. So they have, but they are generally worked down pretty well in the class room. There was once a blacksmith in this country who, while pounding iron, by great industry and persistency, and aided by a wonderful memory, became the master of fifty languages. He was called the learned blacksmith. There has been but one learned blacksmith in America, while each day at evening thousands of blacksmiths who have pounded iron all day go home to their families with tired muscles, in no fit condition for a tussle with roots and conjugation. Here and there there may be a professor who can pound iron in the class room all day and write learned books or conduct deep investigations during his spare hours, but they are about as rare as learned blacksmiths.

Nor need our colleges suffer seriously by putting the strongest men at the head as investigators. All studies that have much drill work in them—and three fourths of college work is steady drill—are taught in our leading institutions by instructors and assistants. If we can not have men of first grade in both station and college, let us have them in the station and let us turn over our general instruction to the assistants. These assistants can do excellent work in all the ordinary routine of teaching, such as chemistry, physics, botany, horticulture, veterinary science, and all the

other branches common to agricultural colleges. Of course I would have strong men in both places were it possible, but I refer to cases where we are unable to reach this high result. Thus you see my idea is to put the station ahead of the agricultural college in the grade of men employed provided both can not be of first rank.

But I would use our investigators for teachers, bringing the students to them for the final polish—for rounding out the subjects under consideration—after each has had thorough drill under the best assistants the means would provide. The investigators being the strongest men in the institution, were we to bring a class to them one hour a day for one term in the year, they would impart instruction of the highest possible grade. And the student, brought in contact with such men in the closing days of his college life, would receive an impulse and gain a grasp of agriculture in its scientific phases that is impossible to impart to him in any other way. Drilling a student day after day in the elements he must master in order to attain the higher lines of the study requires one kind of teaching; to inspire him to a broad comprehension and a worthy grasp of the subject calls for another kind of teacher, and that teacher above all others is he who comes to the class room fresh from his field of investigation with mind loaded down with the information he has been acquiring and full of enthusiasm for his chosen subject. Under this system we can secure the highest sort of investigation in our stations, while the young men as they leave the college will carry an inspiration and an ideal with them that can be gained in no other way.

I believe the combination system which I have been deprecating is only another of those incidents of pioneer effort. It has been practically out of the question in many cases to find suitable persons for manning the station, and very wisely the college authorities have kept the direction of the station in the hands of the president and used the teachers as best they could for investigators. Under this system some excellent work has been done; indeed, some of the very best that has been sent out has come where this combination is practiced, but in such cases the good work has come from our very strongest institutions, those that from their very nature should prove leaders. I believe the time is not far distant when such institutions will adopt the division of labor somewhat after the method I have mapped out.

In all that has been said I have tried to convey the impression that our work as station investigators is even yet in its pioneer stage, and as a consequence there is much that is necessarily crude and irregular. Conceding that we have all made mistakes, I maintain, as was stated in the beginning, that they are errors of the judgment and not of the heart. I believe that almost without exception our station workers are honest in their efforts and earnest in their desire for the upbuilding of agricultural science. But as I look over the field I am deeply impressed with the fact that our work does not yet compare favorably in many cases with that of the older stations of Europe. These shortcomings and mistakes are incident to pioneer effort, and for the most part could not have been avoided. Let us study more carefully than ever before the work of those great institutions of Europe, using them as models whenever we can to help us on. Let us draw our work closer together, undertaking less, laboring more faithfully and more persistently. Let us grow out of amateur efforts into the true scientific spirit. Already we have gained a strong hold on our people and most cordially are they upholding us in our efforts. May each year see the cause strengthened until our stations shall become an integral portion of our agricultural system, and recognized leaders in all agricultural thought.

President Henry then took the chair and in a few well-chosen words introduced Sir Henry Gilbert, of England, to deliver an introduction to six lectures to be given by him in this country on the work of the Rothamsted Experiment Station covering a period of fifty years.

Mr. GILBERT. Mr. President and gentlemen: I thank you for the kind observations which you have made and the kind way in which

they have been received. I have to acknowledge this kindness, not only on my own part, but in behalf of Sir John Lawes. You know—I think he has given you evidence enough of it—that he takes the greatest possible interest in the progress of agriculture, both practical and scientific, on this great continent; and as for myself, those of you whom I met on my two visits to this country know that I spent my time in making myself acquainted with the agriculture of the country and in making the acquaintance of my fellow workers on this side. I will not say that my interest is second to that of Sir John in what is going on among you, and I must say that I have been extremely interested in the remarks of your president, and that I entirely and heartily agree with him in his observations as to the impossibility of uniting active teaching with work of investigation except in a general way. Sir John Lawes and myself have so strongly felt this from the beginning that when asked to allow students to come to Rothamsted it has always been refused; and Sir John has made especial provision that the work of investigation shall be continued and that no part of the fund donated shall be devoted to educational purposes.

You will ask, perhaps, why is it, then, that I went to Oxford as professor for six years. It was simply because in no other way would it have been possible to have presented a great amount of results of investigation at Rothamsted; so I undertook to give lectures at Oxford to bring into form results that would otherwise have been left until now. So that is perfectly consistent with our views of not mixing the work of investigation and education. While I say that we always refused to take pupils at Rothamsted, we said you are perfectly welcome to come and read with others. We will give you no systematic instruction, but if you can learn anything we shall be very glad indeed to let you have the records; and so it is that we have had no systematic teaching, and we believe that if we should have had our investigations would not be where they are now.

Gentlemen, as you know, I have come to this country to deliver somewhere a course of six lectures, giving a résumé of the work covered at Rothamsted for the last fifty years. If you will allow me now I will read an introduction to those lectures.

AGRICULTURAL INVESTIGATIONS AT ROTHAMSTED, ENGLAND.

[Introduction to six lectures on the agricultural investigations conducted for a period of fifty years at Rothamsted, England; delivered under the provisions of the Lawes Agricultural Trust, by Sir Joseph Henry Gilbert, M. A., PH. D., LL. D., F. R. S., V. P. C. S., etc.]

As you are doubtless all aware, it is under the auspices of the Lawes Agricultural Trust, which provides for the periodical delivery in the United States of a course of lectures on the Rothamsted investigations, that I appear before you to-day. Had the occasion been an ordinary one it would not be expected that at the age of 76 I should undertake the risks of so long a journey and the responsibility of delivering a course of lectures before this Association of Agricultural Colleges and Experiment Stations. But the occasion is not an ordinary one. Thus, the more systematic exper-

iments at Rothamsted were commenced in 1843, so that the present year, 1893, is the fiftieth of their continuance; and it was considered desirable that under these circumstances something in the way of a general review of the half century's work and results should be brought before you. Obviously, the execution of such a task could only be appropriately undertaken either by Sir John Lawes or by myself, who alone have worked together from the commencement to the conclusion of the fifty years. Sir John Lawes is, however, even more heavily handicapped by age than I am myself, and at the earnest desire both of Sir John and of the trust committee I have accepted the responsibility.

I need not go into much detail as to the origin, scope, and plan of the Rothamsted investigations. These points were pretty fully considered by Mr. Warington in his first lecture in 1891, and a good deal of information on the subject will be found in the early pages of the now annually issued "Memoranda of the Origin, Plan, and Results of the Field and other Experiments, conducted on the Farm and in the Laboratory at Rothamsted." Indeed, I am sure you will readily understand that it is no easy task to compress within the limits of half a dozen lectures anything like an adequate account of the labors of a gradually increasing staff of workers over a period of fifty years. This must be fully recognized when it is borne in mind that the reports and other papers on the results at present number about 120, and that they occupy nearly 4,000 octavo and more than 800 quarto pages. These publications, moreover, brought together as they have been into bound volumes for the purpose of distribution in a collective form, make up 6 octavos and 3 quartos, while papers since published are accumulating toward another volume. A few years ago 50 sets of the 9 volumes were prepared, requiring the reprinting of nearly 500 octavo pages and the purchase of a good deal of the quarto matter. As many of you are aware, a number of these complete sets of 9 volumes each—I believe 26 sets in all—were presented by Sir John Lawes to as many educational and experimental institutions in the United States, and I am authorized by Sir John to say that he hopes to be able to send perhaps about an equal number more before or about the middle of next year (1894). In all 125 sets, involving the reprinting of about 1,100 pages octavo, and about 370 pages quarto, are now in course of preparation. Of these our own board of agriculture takes 50 to distribute to various institutions in the United Kingdom. There will then be left only 75 sets for distribution by Sir John Lawes himself to our colonies and to foreign countries, including those still to be sent to the United States. It may be added that to provide any more sets than those now in preparation would necessitate further reprinting almost in proportion to the number required; and when it is considered how much time must be expended in the revision of the reprints and how great the cost, little surprise can be felt at the delay in the completion of the work and the necessary limitation of the number to be provided.

Unfortunately, however, besides all the published matter, there still remain large arrears of as yet unpublished results. It is from this mass of material, published and unpublished, that I have to make my selection in endeavoring to give such a view of the objects and results of the Rothamsted investigations as may be of value, both as illustrating the advance in knowledge already attained and as indicating points for future inquiry.

Obviously the scheme proposed precludes the idea of going into much detail on any one subject, and supposes rather a comprehensive, but at the same time only outline, view of the whole. The next question is, whether the illustrations relied upon should have reference primarily to results obtained in the field and in the feeding shed, or chiefly to those of laboratory investigations. Now, as a prominent characteristic of the Rothamsted work has certainly been the devotion of great attention to both field and feeding experiments; and as by far the greater part of the laboratory investigations, whether chemical or botanical, have had for their object the solution of problems suggested by the field and feeding results, it has been thought that the

most appropriate, and at the same time the most useful plan, will be to give a comprehensive view of the plan and results of the field and feeding experiments themselves, and to enforce the lessons which they teach, by such reference to laboratory results as the questions raised require for their elucidation, and as space and time will permit. In other words, the analytical and other laboratory work must be treated as essential means to an important end, and can not, within the limits of such a review, be made the subject of critical consideration as such. And here it should be observed that nothing is done at Rothamsted, in the way of manure or feeding-stuff analysis or seed control, for any purposes external to those of the investigation.

True it is, that although, as has been said, a large amount of field; feeding, and analytical results remains as yet unpublished, yet fortunately a much larger amount has already been put on record. Hence, it may be that some of those before me who are well acquainted with what has been written will be disposed to say as I proceed that we knew much of this before. On the other hand, probably a larger number of those present are not so well acquainted with what has been written, and a still larger proportion of those who may read these lectures afterwards may feel that the outline only which I can give will serve the useful purpose of assisting them the more effectively to study the fuller published records. Indeed, the object I have had in view throughout has been to afford guidance for further study rather than to attempt the impossible task of giving anything like an adequate account of the results that have been obtained or of specifically indicating lines of inquiry for the future.

It will be appropriate here to explain that, meeting Prof. Atwater two years ago in Germany, he urged the desirability of our sending to the World's Columbian Exposition pretty full illustrations of the Rothamsted work and results, to be exhibited side by side with those to be sent by the agricultural colleges and experiment stations of the United States; and that, on his way home some months afterwards, he paid a visit to Rothamsted, further to urge the plan on Sir John Lawes. A general assent to the proposition having been given, the question arose as to what sort of illustrations should be sent. Finally it was considered desirable to send such a series of exhibits as would serve to some extent as a substitute in case I were not able to visit Chicago on the present occasion; and which, in case I were able to give the proposed course of lectures, would be of service both to myself and to my hearers, in illustration of the facts and arguments I should have to adduce. Accordingly, it will be found that a large proportion of the 44 exhibits that have been sent have for their object the presentation to view of the results of the field experiments, of the nitrogen statistics of some of the crops, of the results of experiments on the question of the fixation of free nitrogen, and of results relating to the amount and to the composition of rain, and of land drainage. There are also plans of the experimental fields, showing their areas and the arrangement of the plots. Unfortunately, there is only one illustration relating to experiments on the feeding of animals. It was, however, intended that a pretty complete series relating to that most important subject should be prepared; but the enormous amount of time occupied and the great hindrance to other work involved in the preparation of the exhibits that have been sent rendered it impossible to complete the original design. Some of the omissions in the execution of the intended list of exhibits will, however, be made good by illustrations embodied in my lectures.

With regard to the amount of the exhibits which have actually been sent, it may be observed that the quantity of wall space originally asked for was from 3,000 to 4,000 square feet; but the area actually covered is 4,786 square feet. To put the thing in another way, 4,000 square feet corresponds to a quarter of a mile in length, a yard high; and the actual space covered (4,786 square feet) corresponds to rather more than three tenths of a mile a yard high; and yet, as above stated, the original design has not been fully carried out.

As a preliminary to any detailed explanation of the scheme of the lectures I propose to bring before you, it will be convenient to call attention to the general arrangement of the field experiments, and also to their extent and duration, as shown in the following table (I), which is No. 29 in the list of exhibits:

TABLE I.—*List of the Rothamsted field experiments.*

	Commenc- ing.	Number of years.	Area, acres.	Number of plats.
Wheat (various manures).....	1843-'44	50	11	34 (or 37)
Wheat (alternated with fallow).....	1851	43	1	2
Wheat (varieties).....	1867-'68	15	4-8	about 20
Barley (various manures).....	1852	42	4½	29
Oats (various manures).....	1869	¹ 10	0¾	6
Beans (various manures).....	1847	² 32	1¼	10
Beans (various manures).....	1852	³ 27	1	5
Beans (alternated with wheat).....	1851	⁴ 28	1	10
Clover (various manures).....	1848-'49	⁵ 29	3	18
Various leguminous plants.....	1878	16	3	18
Turnips (various manures).....	1843	⁶ 28	8	40
Sugar beets (various manures).....	1870	5	8	41
Mangel-wurzels (various manures).....	1876	18	8	41
Total.....		.....	56¼	277
Potatoes (various manures).....	1876	18	2	10
Rotation (various manures).....	1848	46	3	12
Permanent grass (various manures).....	1856	38	7	22

¹ Including one year fallow.

² Including one year wheat and five years fallow.

³ Including four years fallow.

⁴ Including two years fallow.

⁵ Clover, twelve times sown (first in 1848); only 8 crops, 4 very small; one year wheat, five years barley, twelve years fallow.

⁶ Including barley without manure three years, 1853-'55.

The general scope and plan of the field experiments has been to grow some of the most important crops of rotation, each separately, year after year, for many years in succession on the same land, without manure, with farmyard manure, and with a great variety of chemical manures; the same description of manure being, as a rule, applied year after year on the same plat. Besides the experiments on the growth of individual crops year after year on the same land, without and with different manures, so to speak complementary experiments, on the growth of crops in an actual course of rotation, without and with different manures, have been made; as also have others on the mixed herbage of permanent grass land, both without and with various manures. And here it is to be observed that the arrangement of the manures is made entirely regardless of the comparative cost as between plat and plat; the question at issue being entirely one of constituents against constituents, and not of shillings against shillings, or dollars against dollars.

It is obvious that the results of field experiments with the individual crops of rotation conducted as above described, must of themselves throw much light on the characteristic requirements of the particular crop under investigation; whilst those on the growth of crops in an actual course of rotation will serve to confirm and control those obtained with the individual crops, and will, in their turn, receive elucidation from the results with the individual crops. Then again, the results of the experiments on the application of different manures to the mixed herbage of permanent grass land, which includes members of the botanical families that contribute some of the most important of our rotation crops may, independently of their special value in reference to the main objects for which they were undertaken, be expected to afford interesting collateral evidence in regard to the requirements of individual plants thus grown in association, instead of alone, year after year, or in rotation, as in the other series of experiments. Obviously, too, the chemical, and in some cases the botanical, statistics of the various crops so variously grown, and the chemical

statistics of the soils of the plats upon which they have been grown, must afford very important data for further study and elucidation.

An examination of the table will show that the individual crops grown separately year after year on the same land, include wheat, barley, and oats, as members of the gramineous family; beans, clover, and other plants, of the family *Leguminosæ*; turnips of the *Cruciferæ*; sugar beet and mangel-wurzel of the *Chenopodiaceæ*; and potatoes of the *Solaneæ*. Then the experiments on rotation include those with members of three different botanical families, turnips, of the *Cruciferæ*; barley and wheat, of the *Gramineæ*; and clover and beans, of the *Leguminosæ*. Lastly, there are the experiments on the mixed herbage of permanent grass land, which includes, besides gramineous and leguminous plants, numerous species of other families.

The first experiments were those with root crops, which were commenced in June, 1843, so that the present year, 1893, is the fifty-first of their continuance. The second were those on wheat, commenced in the autumn of 1843, so that the crop just harvested is the fiftieth grown in succession on the same land. The experiments with beans were commenced in 1847, but for reasons that will be fully explained, they have not been continued up to the present time. Those with clover were commenced in 1848, and have been succeeded by others with various leguminous plants, which are still continued. Then, of the other more important series, those on barley were commenced in 1852, and are still in progress, the crop of the present year being, therefore, the forty-second in succession. Lastly, the experiments on an actual course of rotation were commenced in 1848 and are still continued, so that the present is their forty-sixth year; and those on the mixed herbage of permanent grass land were commenced in 1856, so that this year completes the thirty-eighth of their continuance.

It should be observed that many of the experiments were commenced without any idea of long continuance, and it was only as the results obtained indicated the importance of such continuance that the plan eventually adopted was gradually developed. It is, however, to long continuance that we owe some of the most interesting and the most valuable of our results, as will be fully illustrated as we proceed.

The table further shows the area and the number of plats under experiment in each case, and it may be stated that the total area under exact and continuous experiment has been for some years, and is at the present time, from 39 to 40 acres.

The point I have next to consider is: What is the most appropriate order in which to bring the field and other results relating to these various series of experiments before you? As you will readily understand must have been the case, our selection of crops for investigation was influenced by the actual practice in our own country, the separately grown, individual crops being the chief of those entering into our rotations; whilst the course of rotation selected for study was that which is well known as the four course, namely: Roots, barley, leguminous crop (or fallow), and wheat. Obviously, therefore, the most natural order of illustration would be that indicated by the ideas and conditions in accordance with which the experiments have been arranged and conducted; and, notwithstanding the very widely differing conditions of the agriculture of our country and of yours, I think that the order so indicated will be found to be, upon the whole, not only the most convenient, but the most instructive.

Even in our own country we have a great variety of soil and of climate, and, accordingly, great variety in crops and in the order of their rotation; whilst in your more than fifty States and Territories, extending over such vast ranges of country, the mutual adaptations of soil and climate, and consequently the variety of crops, and the order of their alternation with one another when so grown at all are almost infinite. On the other hand, it is to be borne in mind that one of your most important crops at the present time is wheat, a member of the great and widely distributed gramineous family, and not only was it one of the most important of our crops

until it came to be so largely grown by you, but it has been the subject of very special investigations in various aspects, at Rothamsted. Then, maize and the sugar cane are extremely prominent American products, and they, like wheat, also belong to the great gramineous family. True, the conditions under which even wheat is grown are, as a rule, widely different in the two countries, but in some important respects their characteristic requirements are very similar, whether grown in the one or in the other. Maize and the sugar cane, again, in spite of their characteristic differences of requirement, nevertheless show very characteristic similarity of requirement to that of wheat and its allies of the same family. Much the same may be said in regard to leguminous crops, and also to potatoes, as grown in the two countries.

Indeed, I think it will be recognized that, *mutatis mutandis*, the results which have been obtained under given conditions at Rothamsted, are not without their significance and bearing under the different conditions of the American Continent, whilst the modes of experimenting adopted may afford suggestions for the conduct of more or less parallel investigations, varied of course, according to the varied conditions.

In accordance with what has been said, the following list shows in outline the order in which it is proposed to treat of the crops experimentally grown at Rothamsted, and of the laboratory investigations connected with them. It may be explained that Nos. 1 to 6 refer to the crops separately grown.

1. Root crops—turnips, beets, and mangel-wurzels.
2. Barley.
3. Leguminous crops—beans, clover, and various other *Leguminosæ*; also the question of the fixation of free nitrogen.
4. Wheat.
5. Oats.
6. Potatoes.
7. Rotation—root crops, barley, leguminous crop or fallow, and wheat.
8. The mixed herbage of permanent grass land—produce and composition, botanical and chemical.
9. Rainfall and drainage—quantity and composition.
10. Results of experiments on the feeding of animals.

Those of you who have seen the Rothamsted exhibits in the great exposition will recognize that they have been arranged to illustrate the results of the experiments enumerated in the list I have just given, and that the order of subjects is, in the main, the same in the two cases. Indeed, as has been already said, a prominent object in the selection and arrangement of the exhibits was that they should give a comprehensive view of the plan and results of the fifty years' experiments, and that they should also serve the purpose of illustrations to my lectures.

At the conclusion of Sir Henry Gilbert's lecture President Fairchild, of Kansas, delivered an address on "Intellectual development in agricultural education."

WEDNESDAY, OCTOBER 18, 1893, MORNING SESSION.

The Association was called to order at 10:20 o'clock.

Mr. ALVORD. As to the program for to-day the executive committee has issued a program which was intended only as a starter, leaving the convention to determine, after getting to Chicago and seeing the various attractions, how it would conduct itself as to time and duration of sessions. The committee presents as a program for this morning a general business session of the convention. It is believed that if the convention thinks best the business of the Association (or nearly all of it) can be completed at the present session in time to adjourn by half

past 12 o'clock. The afternoon session will be in coöperation with the Congress on Agricultural Education and Experimentation, papers being read from the Sections on Agriculture and Chemistry and Mechanic Arts.

The Association is invited to visit the joint college and station exhibit at the Exposition to-morrow morning at 10 o'clock. I will announce for the sections that they may obtain a hall for meetings at any time on application to the gentleman in charge of the building.

The program was approved.

The PRESIDENT. The Section on Botany and Horticulture will meet in this hall at 4 o'clock this afternoon.

Mr. ATHERTON. I move that a committee be appointed by the chair to nominate officers for the ensuing year.

Motion carried.

The PRESIDENT. The topic for discussion this morning is the relation of the Association to the dairy test at the Exposition.

There has been in progress since May 1 what is thought to be one of the finest pieces of scientific work ever conducted anywhere in the world. It has a number of peculiar features. In the first place it is a public test; in the next place it is a general test. It is of the highest credit to this organization that we are the controlling influences; that the test has been left to be practically managed by delegates of this body appointed last fall at New Orleans. This has been a gigantic undertaking. As I understand, it has taken four trained book-keepers to simply record the figures.

Prof. Scovell, of Kentucky, chairman of the test committee, will present you with the different features of the test. I will, however, not allow him to read all the figures.

Mr. Scovell presented the following paper:

REPORT OF THE COMMITTEE ON DAIRY TESTS.

The rules governing the dairy test at the World's Columbian Exposition, among other things, provided for the appointment of the committee on tests, said committee to be composed of four representatives of the Association of American Agricultural Colleges and Experiment Stations and such additional members as may be furnished by associations or breeders representing breeds competing, one member being allowed each competing breed. This committee was to have general charge of the tests.

At the New Orleans meeting of this Association, by request of Hon. W. I. Buchanan, chief of the department of agriculture, World's Columbian Exposition, this Association nominated to him four members of this committee, namely, M. A. Scovell, S. M. Babcock, I. P. Roberts, and H. P. Armsby, to represent the Association. Subsequently Mr. Buchanan appointed these members, together with other members, as provided for in the rules, and called the committee together in Chicago on the 6th of last February.

The committee there organized by electing M. A. Scovell chairman and H. H. Hinds, representing the Shorthorns, vice-chairman. Mr. Valancy E. Fuller represented the Jerseys, and W. H. Caldwell the Guernseys. At a subsequent meeting the committee elected H. P. Armsby secretary. At this and a subsequent meeting the members of the committee suggested many minor changes in the rules, mainly for the purpose of making the individual cow tests and the breed test uniform as to results.

Following are the essential features of the rules as finally adopted:

First. The selection of the cows for the test to be made by the various cattle associations, respectively, each association to be responsible for the feed and care of its cows. Some criticism has been made as to this feature of the rules, especially as to the matter of feeding. It has been maintained by a few experimenters and others that the committee on tests should have had authority to regulate the amounts and kinds of food to be given the cows, in order to have uniformity in this respect among the different cows and breeds. The advocates of such a proposition do not seem to understand the real purpose of the test. The proposition which they lay down is: Given a certain quantity of food, which breed or cow can make the most butter or cheese from it? Whereas the real problem contemplated by the rules is: Given a cow or a breed, how can she or it be best handled and fed in order to produce the greatest profit to the owner? This problem is what brought the breeds here to battle for supremacy, and it is well that the responsibility of the selection, care, and feeding devolved upon the cattle associations, for it undoubtedly brought the best cows available for the purpose of the different breeds competing into the test, and it will also prevent the different associations competing from claiming that had the cows been handled differently or fed by those who knew them best the results would have been otherwise.

Second. The rules provide for four tests, the net profit produced by any cow, cows, or breed during any test to be the basis of awards. In all the tests the food eaten by any cow to be charged to her at a fixed price for the different articles, the price being fixed by the chief of the department of agriculture, based upon the average market prices of the various articles at the time the rules were drawn.

TEST NO. 1. *The cheese test.*—Time assigned, fifteen days, May 10–25. The breeds competing were the Jerseys, Guernseys, and Shorthorns. Number of cows in each breed, 25; total number, 75. The awards in this test to be based upon the value of the cheese and whey made and the increase or decrease in live weight, less cost of food. The milk from each breed to be kept separately and made into cheese by uniform methods, the cheese to be cured, and then rated by expert judges. A fixed scale of prices was laid down for cheese, depending upon the rating, prices varying between 8 and 16 cents. The price of whey was fixed at 8 cents per 100 pounds. Each cow to be weighed the first five days of the test, the average of these five days to be taken as her weight at beginning of test; also to be weighed in like manner at end of test. If the last average weight showed an increase over the first weight, such increase to be credited to the cow at $4\frac{1}{2}$ cents per pound. If she decreases in weight such decrease to be charged against her at $4\frac{1}{2}$ cents per pound. Each cow to be credited each day with that proportion of the cheese made by the herd to which she belongs, which the total solids found in her milk bears to the total solids of the breed, and with that proportion of the whey which her milk bears to the total milk of the herd.

TEST NO. 2. *The ninety-day butter test.*—Time, from June 1 to August 29. The cows in cheese test alone eligible to this test, with the exception that two alternates from each breed might enter this test. Number of cows in test, 75.

Awards in this test based upon value of butter, skim milk, and buttermilk produced, and gain or loss in live weight, less cost of food consumed. The milk from each breed to be kept separately and creamed separately by a uniform approved mechanical process; cream to be handled and churned by uniform method for each breed.

Butter color, if used, to be charged against breed using it at usual prices, butter to be sampled and the amount of butter fat to be determined in the butter of each breed daily. Credit to be given for the number of pounds of butter containing 80 per cent of fat, which such amount of fat would make.

Uniform packages of butter to be preserved for rating, and scored weekly. Butter to be credited according to a sliding scale of prices based upon the score. The prices were agreed upon before the tests began and were supposed to represent the

average retail price of the finest butter at the time. The skim milk and buttermilk to be weighed and solids determined. Solids-not-fat in the skim milk and buttermilk to be credited at 2 cents per pound. Increase in live weight to be credited and loss to be debited, as in test No. 1.

The amount of butter made by any breed daily and the amount of solids-not-fat in the skim milk and buttermilk to be prorated among the cows of that breed. Each cow to be credited with that proportion of the butter made by the herd to which she belongs, that the amount of fat found in her milk by analysis bears to the total amount of the fat found in the milk of the herd, and with a similarly ascertained proportion of the solids in the skim milk and buttermilk found in the herd.

TEST NO. 3. *The thirty-day butter test.*—Any cow, Jersey, Guernsey, or Shorthorn, to be eligible to this test. Number of cows from each breed, 15. Total number of cows, 45. In this test the Jerseys substituted 3 fresh cows, the Guernseys 5, and the Shorthorns 4, the other cows in the test being carried over from tests Nos. 1 and 2. Credit to be given for butter alone in this test. Awards to be based upon value of butter, less cost of food.

In this test the superintendent of a herd had the right to designate how the milk of the herd should be handled at the dairy and how the cream should be separated and butter made. The choice was also given him to have the milk of individual cows churned separately. Otherwise the methods were the same as in test No. 2.

TEST NO. 4. The rules provided for a young herd test, animals to be of same breed as competed in other tests and not to be over 3 years old on September 1, 1893. The awards to be based upon the same condition as test No. 2, the ninety-day test. Subsequently, however, on recommendation of the committee, the rules governing this test were changed as follows:

“Saturday, September 30 to October 20, inclusive, 21 days. Breed test No. 4.—This test will be of young herds entered in accordance with Section 7 of the rules, and will be conducted under the same conditions and requirements, and the awards will be upon the same basis as provided for in Test No. 2, except that the amount of 80 per cent butter produced be calculated from the fat in the milk from day to day as found by analysis, and that the butter so found be rated at the uniform price of 40 cents per pound, and that credit be given for all of the solids-not-fat in the milk at the rate of 2 cents per pound.”

Two breeds competed—the Jerseys with 7 heifers and Shorthorns with 6.

The rules provide against substituting one cow for another, against giving stimulants, and against giving medicine except by official veterinarian, and excepting certain nonstimulating drugs specifically named which could be given if the operation were witnessed by a number of the committee, not the superintendent in charge. They also provide that the cow shall be milked at stated times and only in the presence of a member of the committee or its representative. That the milk shall be weighed and an aliquot sample taken for analysis, and that in case of sickness of the cow she shall be dropped from the test, until reinstated by the veterinarian. If sick longer than seven days or if she dies, she shall be credited thereafter with the average quality and quantity of the milk given on the first three of the ten days prior to her sickness, increased or decreased by the per cent of increase or decrease of the products of the herd to which she belongs. Such estimates to be specially noted in the records. (This was necessary to provide for constant comparison of an equal number of cows in the several breeds.)

In case the weight of milk from any cow or breed is lost, the average of the corresponding weights for the two days preceding and two following shall be credited to such cow or breed. In case any sample is lost its composition shall be assumed to be the average of that of the corresponding samples for the two previous days, and the cow or breed shall be credited accordingly. If the weight of butter be lost, its amount shall be calculated from the amount and composition of the milk on the basis of the average results in skimming and churning, or cheese-making, obtained for the same breed during the two days previous and the two following.

It was evident to the committee that the plans for everything necessary in carrying out the tests under these rules should be thoroughly considered and well matured before the tests began, in order to secure successful accomplishment. One of the most important things to be considered was how to keep a constant watch over the 75 cows which entered the tests, in order that results might be trustworthy. To accomplish this purpose, guards were stationed in each of the dairy barns both night and day, with positive instructions to allow no food to be brought into the barns or to be given to the cows except when the properly authorized person was present to attend to the weighing of food, to report any irregularities as to feeding, milking, or giving medicine to cows, to watch the milkers and see that no extra milk or cream was put into the milk buckets while milking.

To assist the committee in their work, three assistants were appointed, one for each of the three breeds. These assistants represented the committee in the barns and were authorized to weigh and record the feed of the cows, to weigh and sample the milk, seal the feed bins and the milk cans and the sample-carrying cans. They were present at every milking and feeding. These men were appointed by the chief of the department of agriculture, on recommendation of the committee on tests, and were generally young men from the stations and colleges. These representatives, as well as the guards, were frequently changed from barn to barn and were under instructions to watch the milkers and feeders in such manner that they could be confident that no irregularities took place.

In order to systematize and facilitate the work the cows were numbered from 1 to 25 in tests Nos. 1 and 2 and from 1 to 15 in test No. 3, and these numbers (and not the names of the cows) were used in all the records.

The scales used were decimal, weighing to one tenth of a pound, and were tested from time to time. The milk pails were uniform in weight and size; the carrying cans were of uniform size and varied but little in weight.

The milk as drawn in each barn was brought to the representative of the committee, who weighed it and recorded the weight. He then poured it into a special sample pail and took a uniform aliquot sample with a sampling tube made especially for this purpose, pouring the sample of milk into a sample jar corresponding in number to the cow. The rest of the milk was poured into the carrying can. Whenever the carrying can was full the milk was mixed and a sample taken by means of a sampling tube, and the sample was put into a sample jar marked X.

There were provided for taking samples a number of sets of 26 one-half pint Mason sample jars. Each set was placed in a galvanized iron box of just the right dimensions, and containing handles and a cover, which could be easily sealed. The sample jars were numbered 1, 2, 3, to 25, and X. The different sets were of nearly uniform weight.

After the milking and sampling were finished a member of the committee or one of its representatives sealed the carrying can and the box of samples. The former was sent to the dairy building and the latter to the laboratory. Subsequent milkings of the same day were treated in the same manner, the sealed box containing the samples being brought from the laboratory and opened in the presence of the superintendent of the breed or his representative and of a representative of the committee, and the samples from the same cow being united. After the last milking of each day the sealed boxes of samples were collected and taken to the laboratory for analysis. The sample box was weighed empty before it left the laboratory and again when it returned from the barn after the last milking. This, together with the weight of the milk taken at the dairy, gave a check on the weights of milk as reported by the committee's representative taken at the barns.

The work in the laboratory was under the direct charge of Dr. E. H. Farrington, chemist of the University of Illinois Experiment Station. Associated with him were five and sometimes six assistant chemists, selected from the various stations, and who were especially fitted for the work in hand. Dr. Farrington organized the

assistant chemists in two divisions. Each division working independently on the same samples, thereby insuring strictly independent duplicate work. The fat in the milk was determined by the Babcock test and the solids-not-fat by the Quevenne lactometer. The butter was analyzed by the official method.

Dr. Farrington deserves much credit for the manner and skill in which the laboratory work was carried on. He had many difficulties to contend against, but the results show conclusively that he was the right man in the right place. Dr. Farrington made his report daily to the committee, handing in the original results as well as the average of duplicates for the inspection of the committee.

When received at the dairy the seals upon the cans containing the milk were examined to see that none were broken, after which the cans were opened by a member of the committee or by its representative. The milk from each breed was then thoroughly aerated and cooled. The can containing the milk was then placed in a refrigerator room and kept there under lock and seal until the separating, which was done each morning between 9 and 11 o'clock.

The milk from each herd was weighed just before separation, the difference between this weight and the weight of milk in the barn, less the weight of samples, giving the mechanical loss. This loss usually amounts to from 5 to 7 pounds, and any wide discrepancy from these figures showed error in some part of the work, which was immediately investigated. When such discrepancy could not be satisfactorily accounted for the yield of butter for the day was estimated according to rule 20. Necessity for such action occurred only once or twice during the whole test. The total milk for each day from each herd was mixed together in a receiving vat and warmed to a proper temperature for separation. After separating with the centrifugal the skim milk and cream were both weighed as a check upon the first weight taken. Samples of skim milk were taken for analysis with a Scovell tube in the same manner as from the mixed milk. The cream was immediately cooled to a proper temperature for ripening and placed under seal until churned; when ready to churn the cream was again weighed and the weight compared with the weight when first separated, in order to detect any loss in handling. When churned, a sample of the buttermilk was taken for analysis in the same manner as that of the skim milk. When salted and worked, while spread upon the worker, a sample of butter was taken for analysis by taking small portions from different parts of the worker. It is believed that fairly representative samples were obtained in this way. The butter was then removed from the worker and weighed, together with the sample taken for analysis. A 5-pound package of the worked butter was packed for the judges and placed under seal in a refrigerator until judged. The butter was judged every week by three judges, who made their scores independently of each other, the butter from each breed being designated by number, no one being present except the judges and the attendant who brought the butter to them. When completed each judge placed his individual score in an envelope addressed to Chief Buchanan, who, after removing the signatures, sent the scores to the committee.

Throughout the whole test each step of the dairy work has been carefully watched by some member of the station committee or its representative, and every precaution against fraud or error has been taken.

During the cheese test similar precautions were taken to guard and care for the milk previous to manufacture. Separate vats were provided for the milk from each herd into which the milk was weighed and made into cheese on the Cheddar plan by expert cheese-makers. When taken from the press the cheese was weighed and a lead seal similar to those used upon the milk cans was affixed to each to designate the kind of milk from which it was made. The cheese from all of the breeds was kept in the same room, which was locked and sealed, no one being allowed to enter it except in the presence of a member of the committee. When properly refined the cheese was judged by three judges appointed by Chief Buchanan, the same precaution being taken as with the butter, the judges being in every case ignorant of the kind of milk from which the cheese was made. In both the cheese test and the

ninety-day butter test, the milks from the three herds were handled as nearly as practicable in the same manner as provided for in the rules governing these tests.

The question of blanks for keeping the records occupied the attention of your members of the committee as early as February. After many consultations and considerable work, a set of blanks was adopted which have worked very satisfactorily. A series of small blanks of original entry were provided as follows:

A blank for feed records, a blank for milk records, a blank for laboratory milk record, a blank for dairy records, a blank each for buttermilk, skim milk, and butter analysis records, and last, a ledger record on which the figures from the original entry blanks were copied each day and the necessary computations made.

The original records were made in duplicate by means of carbon paper, the original being delivered at once to the secretary of the committee and the duplicate copy given to the superintendent of the breed which it represented.

At the daily meeting of the committee the original entries were submitted to the superintendents of the respective breeds for approval.

The test has been unique in many particulars. It has furnished opportunity for the study of dairy problems such as could only have been secured under the auspices of such an organization as the World's Columbian Exposition and such as may never occur again.

The cows entered were picked representatives of their respective breeds, selected by experts in the most careful manner and in number sufficient to afford as fair representation of the breeds as we can ever hope to attain. These cows were fed and handled throughout the test by persons fully conversant with the breed and individual peculiarities of the animals, and who had had large practical experience in the care and management of dairy stock.

The test was of sufficient length to fully test the staying capacity of the cows, some individuals having been under continuous observation for four and one half months. The records of the test, as provided for in the rules, are of the most complete character, and every precaution that ingenuity could suggest was provided to secure absolute accuracy and trustworthiness.

In brief, the test represents an unusual combination of the best practical skill and the best available scientific methods, under conditions such that the results are put beyond reasonable doubt as to accuracy.

This has not been attained without extraordinary expenditures. While no complete statement of the cost of the test can now be made, the following may serve to suggest its magnitude:

COST OF THE TEST.

A. To the Cattle Association:

1. Selection and transporting cows.....	}	\$48,000
2. Salaries and wages.....		
3. Cows killed.....		

B. To the Exposition:

1. Stables and dairy buildings.....	}	67,000
2. Feed.....		
3. Salaries.....		
a. Dairy force.....		
b. Chemist.....		
c. Clerks.....		
d. Superintendent of feed.....	}	
e. Labor.....		

C. To the stations:

1. Expense of committee.....	}	6,000
2. Time of committee.....		

121,000

There has been, as yet, neither time nor opportunity for careful study and discussion of the vast amount of data accumulated in these tests, but it is already apparent, even in the most cursory scrutiny, that results of the greatest interest and value may be expected from systematic, thorough, and impartial study of the facts now on the records in the books of the committee.

It is our confident belief that these results will be well worth all the expenditure necessary to secure and disseminate them.

The report of your representatives upon the committee would be incomplete without mention of the very pleasant and gratifying relations which have existed throughout the test with the chief of the department of agriculture and with the representatives of the several breeders' associations.

By his unfailing courtesy and unreserved support, his prompt compliance with every reasonable request, and his unstinted recognition of the efforts of your representatives to faithfully perform the duties assigned them, Chief Buchanan has placed us under obligations to him which it is a pleasure as well as a duty to recognize.

Our associates in the committee, too, have met us in the most friendly manner, and the whole committee has worked harmoniously together throughout to secure what all had at heart, an absolutely fair, accurate, and unprejudiced test.

Mr. ATHERTON. While Prof. Scovell was reading it occurred to me that this was a fitting time to express to this committee our appreciation of their work, and I have hastily prepared a resolution which I will read and ask that it be referred to the proper committee:

Resolved, That the thanks of this Association be, and hereby are, conveyed to the committee on dairy tests at the Columbian Exposition for the thoroughness, fidelity, and skill with which they have discharged the very important but burdensome duty intrusted to them, a public service which reflects the highest credit upon the individual members of the committee and upon the Association of American Agricultural Colleges and Experiment Stations, which they have so ably represented.

Mr. ALVORD. I take pleasure in announcing that the executive committee pass at once upon this resolution and unanimously report it favorably for action.

The resolution was adopted.

Mr. ALVORD. I have a few additional resolutions to submit from the executive committee bearing upon the same subject. The committee submits the following, with the recommendation that they be now adopted:

Resolved, That the standing committees of the Association on the collective college exhibit, the collective station exhibit, and the dairy test at the Exposition be continued, with authority to file final reports with the executive committee as a part of the proceedings of the Association for this year.

Resolved, That the Office of Experiment Stations of the Department of Agriculture be requested to make a report of its exhibit to accompany the corresponding reports of the Association committees.

On motion the resolutions were adopted.

Mr. DABNEY. I rise to call attention to some points and to ask for information. Is it possible to publish the ledger sheets of the dairy test record—is that contemplated? Then again I wish to ask what rights or interest have we in these records?

Mr. MYERS. Is it not the expectation that this report will be published as a part of these proceedings? It was certainly done by station

workers and reported here. Why not print it as a part of the proceedings?

The PRESIDENT. I think that if you will leave this matter in the hands of the committee they will not allow the records to be lost nor allow the stations' interest to be lost sight of. The matter is somewhat complicated. Though the stations have put in a few thousands, the Exposition authorities have put in ten to our one.

I will now announce, as a committee to nominate officers for the ensuing year, Messrs. Atherton, Dabney, Koons, Thorne, Gulley, Cavitt, and Hays.

Mr. ATHERTON. May I ask if the committee have leave to retire?

The PRESIDENT. Yes, sir.

Mr. TRUE. As chairman of the committee appointed to draft suitable expression of our appreciation of the foreign educational exhibits, I submit the following resolutions:

Resolved, That this Association greatly appreciates the value of the exhibit of the Rothamsted Experiment Station made by the Lawes Agricultural Trust at the World's Columbian Exposition, and it seems fitting that some official expression of appreciation of this exhibit should be made by the authorities in charge of the Exposition.

Resolved, That copies of these resolutions be sent to the proper authorities of the Exposition and to the commissioner in charge of the exhibit of the Rothamsted Experiment Station.

A. C. TRUE,
J. H. WASHBURN,
J. A. MYERS,
Committee.

Resolved, That this Association greatly appreciates the value of the exhibit of agricultural schools and experiment stations made by the Government of France at the World's Columbian Exposition, and it seems fitting that some official expression of appreciation of this exhibit should be made by the authorities in charge of the Exposition.

Resolved, That copies of these resolutions be sent to the proper authorities of the Exposition and to the commissioner in charge of the French exhibit.

A. C. TRUE,
J. H. WASHBURN,
J. A. MYERS,
Committee.

The resolutions were adopted.

Mr. SCOTT. If in order to submit a report from the Section on College Work I should like to bring the following resolution before the Association.

The Section on College Work recommend the adoption of the report of its chairman on "The Instruction in Military Science and its Needs," and submits the following resolutions for the consideration of the Association:

Resolved, That this Association heartily approves of the recommendation of the Inspector General of the Army in his report for 1892, that such legislation be had as will enable the Secretary of War to supply the military departments of the land-grant colleges with the necessary uniforms and camp and garrison equipage; and

Resolved, That the executive committee is instructed to confer with the proper authorities on this subject and take such other action as may be found necessary to secure the favorable consideration of this recommendation.

On motion of Mr. Bondurant the resolutions were adopted.

Recess was then taken for twenty-five minutes.

Mr. Alvord, on the convention being called to order, presented the following resolutions from the executive committee, with recommendations for their adoption:

Resolved, That the new executive committee be instructed to inform by circular all the colleges interested, of the terms upon which the bust of Hon. Justin S. Morrill can be obtained.

On motion the resolution was adopted.

Resolved, That the dues of institutions eligible to membership in the Association for the ensuing year be fixed at \$15.

Adopted.

Resolved, That the executive committee be charged with editing and publishing the proceedings of this convention, in coöperation with the U. S. Department of Agriculture.

Adopted.

Resolved, That the unfinished business of the Association be referred to the executive committee for action at its discretion.

Adopted.

Concerning the resolution of Mr. Kellogg, regarding the distribution of seeds and plants, the committee reports that the proposed action is inexpedient at the present time and recommends that it be laid on the table. Action approved.

Concerning the resolution, introduced by Mr. Cavitt, regarding action to be taken by the Association on the proposed legislation repealing all permanent appropriations (which will include the Morrill Act of 1890), the committee regards the matter as of the highest importance, but it is believed inexpedient to take definite action at present, and therefore recommends that this preamble and resolution be referred to the new executive committee.

Mr. CAVITT. Does that mean that it will be postponed until next year's meeting?

The PRESIDENT. It is in their hands for action at any time. The executive committee represents the Association *ad interim*.

Reports from sections on nominations of officers are now in order. First, the report of the Section on Agriculture and Chemistry.

Mr. FREAR. We report the following nominations: Messrs. Henry, chairman; Brooks, vice-chairman; and Voorhees, secretary.

Nominations confirmed.

Mr. STOCKBRIDGE. The Section on College Work reports the following nominations: Messrs. Fairchild, chairman; Harris, vice-chairman; and Stockbridge, secretary.

Nominations confirmed.

Mr. LAZENBY. In absence of the secretary I report for the Section on Botany and Horticulture nominations of the following as officers for the ensuing year: Messrs. Goff, president; Taft, vice-president; and Pammel, secretary.

Nominations confirmed.

Mr. COMSTOCK. For the Section on Entomology I report the following: Messrs. Osborn, president, and C. M. Weed, secretary.

Nominations confirmed.

Mr. HALL. For the Section on Mechanic Arts, I report for chairman, Mr. Washburn, and for secretary, Mr. Anderson.

Nominations confirmed.

Mr. HARRIS. As chairman of the auditing committee, I respectfully report that the committee have examined the accounts of the treasurer and have found them correct, with proper vouchers for every item of expenditure.

Report accepted.

Mr. LAZENBY. I wish to say that I am authorized by the trustees and faculty of the Ohio State University to invite this Association to meet at Columbus, Ohio, at its next session.

Referred to the executive committee.

On motion of Mr. Myers, it was decided to attend the Exposition the day following and to meet at the exhibit of the Office of Experiment Stations in the Agricultural Building.

On behalf of the officers of Cornell University, Mr. Roberts extended an invitation to the Association to hold its next meeting at Ithaca, N. Y.

Mr. THORNE. I have asked permission of the executive committee to occupy a little of your time. I have a short paper which I wish to present.

HOW CAN WE INCREASE THE ATTENDANCE OF STATION OFFICERS AT OUR ANNUAL CONVENTIONS?

The Association of American Agricultural Colleges and Experiment Stations was called into being by the necessity which those charged with the organization of agricultural investigation in America, under the so-called Hatch Act, felt for conference with each other, in order that this new work might be established with the fewest possible mistakes; and in the first year of our work there was no topic which more urgently demanded our time and thought than those relating to general administration. But it is now nearly six years since the Hatch Act went into effect, and this is the seventh general convention of our Association. Most of our stations have passed through the experimental stage in their organization, and have found and settled into such lines of work as seem best suited to their various conditions and environment. There will, of course, always be some questions of general policy calling for discussion, but I apprehend that in the future such questions will be few as compared with those which relate more closely to the details of scientific investigation. In other words, and to come squarely to the point, I think the time has come when the attendance of those members of the stations' staffs who are most directly concerned in the work of investigation should be looked upon as even more desirable than that of the directors themselves; and I would say the same with reference to those who are charged with the work of instruction in the colleges. The college

presidents have done a most useful work, and one which no one else could have done in the organization of this Association, but the time has now come when the very life of the Association demands that they should earnestly plan for participation in its work by such members of their faculties as are engaged in the various departments of research and instruction which come within the scope of our Association's work.

I think I need not stop to argue this point. The Association itself, by practically unanimous action, has decided to enlarge its work, from the mere adjustment of relations between college and station and the coöperative action of all in matters of general policy, into a field which covers the entire work of the American college of agriculture and the mechanic arts and the agricultural experiment station, a field as broad as the universe.

Having set this high ideal before us—and wisely, I believe—how shall we proceed in order to attain the largest possible measure of success? One or two of our shortcomings I shall try to indicate, and in doing so, I wish it to be distinctly understood that I am making no personal criticisms. I believe that every man who has been charged with responsibility in the conduct of this Association has had its interests at heart, and that any falling short of the best possible attainment should be charged to the overload of other duties which too many of us are forced to carry, and not to any intentional neglect. The fact is, that thus far our annual conventions have steadily increased in interest and value, and it is only because I see in some quarters indications of a lack of appreciation on the part of some of those who should be most benefited by the opportunities which these meetings offer that I venture to make any suggestions. For instance, it is not encouraging to look over the report of our meeting at New Orleans and observe that horticulture had but four representatives at that convention, and entomology but two, yet these are two of the most important departments of station work.

One of the chief causes of this lack of appreciation has been the lack of preparation for the convention. When the various sections were first organized it was expected that sectional programs would be prepared and distributed in advance of the convention, but the instances in which this expectation has been realized have been too few to enumerate. Now, it is utterly useless to expect that a man whose work is confined to a single specialty will spend from \$30 to \$50 a year out of the too meager salaries which most of our station workers receive for the purpose of attending a meeting where no provision has been made for consideration of the problems in which he is most interested. Our sections in agriculture and chemistry have always had a fair attendance, and the reason is obvious. Most station directors are either agriculturists or chemists; but it is evident that there must be a decided change if our conventions are to become a general rendezvous for all workers in scientific investigation in agriculture.

Another cause of apathy on the part of those who are neither station directors nor college presidents is to be found in the practice of sending delegates to our conventions at the expense of the colleges and stations. While we were passing through the organizing stage of our work it was perfectly legitimate that the various institutions represented should pay the expenses of their delegates, but we are past that period now. The American agricultural experiment station is on its feet and is a power in the land, and the question whether it shall retain this position lies with the men who are doing its work; but the man who has not ambition enough to impel him to spend a few dollars yearly for such opportunities of improvement as the conventions of this Association should offer is not worthy of a place in the work and will not long be permitted to retain such a place.

But station workers are like the rest of humanity, and those who are not so fortunate as to have their expenses paid to our conventions naturally feel that it is an injustice that this favor should be shown exclusively to those who are already receiving larger salaries than they, and as a consequence they stay at home or organize themselves into independent societies or join some section of the already overloaded American Association for the Advancement of Science.

I observe, for instance, that at the recent Madison convention of this general association there were well-attended sections in botany and entomology; yet the work in these sections was chiefly done by experiment station men, that in entomology being almost altogether economic and that in botany chiefly so. But this is work that should first appear in the proceedings of our Association, and will do so if we use the proper measure to bring it to us. The idea should be inculcated that the upbuilding of this Association is something more than a privilege on the part of station workers, and if it comes a little awkward on the part of us directors and presidents to insist that our associates shall put their hands in their pockets to develop the scientific work of the Association, while we are having a good time together without expense to ourselves, I think we should at least be willing to divide with them. Thus far our work has had very smooth sailing at Washington, but when Congress comes face to face with a deficit in the National revenues instead of an unmanageable surplus we may expect a close scrutiny of experiment station work. When the work was being organized we could only offer promises, and our promises were accepted, but when the next crisis comes promises will be of no avail. Results will be demanded then, and we shall need to be ready to put forward these results in the most concrete form.

Now, if I were sure that we were ready for them, I would ask this convention to adopt three resolutions, the first of which would be a suggestion as to the expediency of making a more general distribution, or none at all, in the payment of the expenses of station and college officers as delegates to our conventions; but as I realize that this might seem like a hardship in the case of the stations most remote from the place of meeting I merely drop the suggestion and pass to the next, for which I ask the usual reference and final consideration of the convention:

Resolved, That the chairman and secretary of each section of the Association are constituted a committee on program for that section, and that it is made their duty to prepare and submit to the chairman of the executive committee, within twenty days after publication of the call for the next annual convention of the Association, a program for the work of their section in that convention, said programs to include not less than six papers each.

Resolved, That it is the sense of this convention that all scientific workers who are supported wholly or chiefly from funds appropriated by the National Congress for the encouragement of scientific instruction and investigation in agriculture, under the acts known as the Morrill and Hatch acts, should look upon it as a duty to so use the results of their investigations that due credit may unmistakably accrue to the American agricultural experiment stations, separately or collectively.

In other words, I mean by this last resolution that we should say, and I think we should say it emphatically, that in the proceedings of this Association is the proper place for the first publication in full of such papers as appropriately appear in the proceedings of scientific societies, when such papers are the results of work paid for out of these National funds.

Let me illustrate a little: I employ a man to work my farm and pay him a stated salary by the year. He plants and cultivates and harvests my crops, but has he any right to sell or even give away any portion of these crops? or has he any right to go across the road and work a day occasionally for my neighbor without accounting to me for the time? I am employed to edit a newspaper, with the understanding that I am to give my entire ability to that work; have I any right, while so employed, to use the information and experience which I acquire in that work in conducting a newspaper across the street? Yet I have known station workers to do what would be the exact equivalent of what I have described. It will not do to say that this work is all for the public anyhow and it does not matter how it gets to them. It does matter, for the continuance of the work depends upon the people understanding definitely what they are getting for the money they are putting into it.

Mr. ATHERTON. I suggest that we adopt the two resolutions presented. I would like to ask for a report from the executive committee.

Mr. ALVORD. The committee reports the resolutions back without recommendation.

Mr. FREAR. Does the last clause of the resolution mean that no results of scientific work of station men shall appear before appearing in a station publication?

Mr. THORNE. No; but that credit shall unmistakably be given to the station.

After some discussion the resolutions were adopted.

Mr. Harris offered a resolution inviting such inspection of the work of the stations as might be deemed proper, which, after some discussion, was adopted in the following form and as an instruction to the new executive committee:

Resolved, As the sense of this convention that this Association would welcome, on the part of the United States authorities, such inspection of expenditures by the several stations established under the act of 1887 as may be deemed proper by the General Government.

Mr. ATHERTON. If in order, I would like to submit the report of the nominating committee. I am directed by the committee to present the following nominations for officers of the Association for the ensuing year:

President, S. D. Lee, of Mississippi.

Vice-presidents, G. E. Morrow, of Illinois; J. S. Newman, of South Carolina; H. Hadley, of New Mexico; J. H. Canfield, of Nebraska; and William Frear, of Pennsylvania.

Secretary and treasurer, M. A. Scovell, of Kentucky.

Bibliographer, S. W. Johnson, of Connecticut.

Executive committee, H. E. Alvord, of the District of Columbia; H. C. White, of Georgia; A. W. Harris, of Maine; H. H. Goodell, of Massachusetts.

The nominations were accepted and the persons named were duly elected and declared the officers of the Association for the ensuing year.

The following resolution in regard to annual meetings was presented by Mr. Rose, of Texas:

Resolved, That the executive committee be instructed to consider the advisability of holding our annual meetings during the month of June, July, or August.

Mr. Cavitt offered the following resolution in regard to the name of the Association:

Resolved, That the name of this Association shall be so changed as to hereafter read as follows: "American Association of Agricultural and Mechanical Colleges and Experiment Stations."

The resolutions were referred to the new executive committee.

Mr. Atherton extended an invitation to the Association to hold its next meeting at the Pennsylvania State College.

The PRESIDENT. There will be a session of the convention this afternoon at 2 o'clock, to be held in conjunction with that of the Congress on Agricultural Education and Experiment. At the session this evening at 7 o'clock papers will be presented by the Section on Mechanic Arts.

On motion of Mr. Bondurant, the convention adjourned at 1:20 p. m.

WEDNESDAY, OCTOBER 18, 1894, EVENING SESSION.

The following papers were presented by the Section on Mechanic Arts:

SHOPWORK INSTRUCTION AT THE IOWA STATE COLLEGE OF AGRICULTURE AND MECHANIC ARTS, AMES, IOWA.

By G. W. BISSELL, of Iowa.

The following is presented, not as embodying new ideas, but as descriptive of old ideas put into practice, and with the hope of provoking discussion by others who have to do with shopwork instruction in the land-grant colleges.

The shopwork instruction is composed of sixteen weeks of carpentry and wood-turning, sixteen weeks of blacksmithing, sixteen weeks of pattern-making, covering the first year and one half of the second year of the course, and sixty-four weeks of machine-shop practice, with which is incorporated some work in the foundry. A week's work in every case consists of eight hours, usually in two shifts of four hours each.

For the instruction of the various classes a machinist, a blacksmith, and a carpenter are employed. These men are skilled mechanics.

The time of the instructors required for the work of instruction to scheduled classes is about three and one half days per week. The shops are open and the machinery running eight hours per day for the six week days. The instructors, when not employed as above indicated, devote their time to the maintenance and making of tools and to the commercial work of the shops. The latter is sufficient of itself to keep them employed and for a good share of the time additional mechanics are employed to do commercial work.

Students are assigned to work at stated hours in sections or classes of convenient size and are expected to be punctual in attendance as per schedule. Each student is given credit daily on the class book for time spent at work and is required to put in the specified number of hours in each shop. Time lost by absence for good cause can be made up as the student may arrange with the instructor.

The student pays for the material used in shop instruction which does not revert to the shop. For this purpose he deposits the sum of \$5 per term with the college treasurer, and an account is kept of charges made against the deposit. These charges include individual material, breakage, fuel for the shop engine, waste, oil, etc., and small tools lost or otherwise unaccounted for. The amount named has been found to more than cover all expenses justly chargeable to students. The balance is refunded.

We have no difficulty in maintaining order in the shops. The incentive to the unwilling student is the time book, the instructor having the right to dock those guilty of disorder, "soldiering," or leaving their tools or benches without cleaning the same.

The work done by the students in the shops is of two classes—exercises and job work. If the student were required to do all the exercises included in the scheme of the course they would serve to keep him employed for more than two years of his

shop course. The plan is, however, to shorten this time by omitting many of the exercises and to assign others taken from the commercial work which is in hand at the time. In general, the beginners spend one term upon exercises. In the succeeding terms the exercises become less and less the rule, and are entirely abandoned in the junior and senior years. The job work forms the most interesting and valuable feature of the shopwork for the advanced students. It consists of selected work from the commercial work done in the shops, and comprises the construction of experimental apparatus for the several departments of the college, the repair and construction of tools, apparatus for the shops of our own department, and work done for parties having no connection with the college. A large proportion of the last class comes from a suburban steam railway connecting the college with the town of Ames. This work is a source of revenue to the department. In assigning job work to the students the judgment of the instructor is an important factor. To show the scope of this feature of our work the following examples are given:

A 4 and 2½ by 6 duplex steam pump has been constructed from drawings and with castings furnished by an Eastern maker. A 6-horse-power vertical engine is now under way. A 10 and 5 by 12 steam pump, belonging to the college pumping station, is being overhauled; this includes reboring the water cylinder and the valve seat. For the former, owing to the limited swing of the largest lathe, the boring will be done with a star feed boring bar, which one of the students has just completed for the job. Two small steam engines have been overhauled, involving such operations as reboring the cylinders, scraping the valves and seats, putting in new crank pins, forging and finishing a connecting rod, rebabbitting the boxes, etc. Two special indicator motions for the engines in the mechanical laboratory. A large amount of apparatus for the department of physics, including galvanometers, a hygrometer, ammeters, linear expansion apparatus, 500 binding posts, the students making the special tools for the same to fit an Almond turret head used on one of the lathes.

A more extended list might be presented, but the above will serve the present purpose. It will be seen that the number of accessory exercises involved in the above, such as the making of special reamers, jigs, etc., is sufficient to fill up many hours of the required time. Useless labor and superfluous finish are not encouraged. The student is taught to economize his time. The reasons for every step are explained whenever such explanation is needed.

The results obtained by the above-described features of our work, as measured by the general interest manifested in the work by the students whom we seek thus to benefit, are all-sufficient. As to the permanent benefit to the student thus placed in an atmosphere of business and competition, the writer thinks that there can be no question.

The words of Dr. R. H. Thurston (p. 761 *et seq.*, vol. VII, Transactions of the American Society of Mechanical Engineers) bear directly on this point and are here quoted:

"The question as to whether the shop shall be a business establishment as well as a school, or simply the latter, is a very interesting one. * * * For my own part, I have watched the progress of the two systems very carefully, and can see the advantages claimed for each very clearly; but I see no reason why the advantages of both plans should not be combined. * * * There can be no question that to teach the use of tools first is the first and indisputable duty of the instructor, and that, the use of the tool being once taught, its application in the arts is no less his second and no less imperative duty. I should therefore first attempt systematically and thoroughly to teach the entering pupil the use of the tools of his art. This can undoubtedly best be done by a series of graded exercises. * * * The progress which can be made by the skillful application of this system of exercises is astonishing to one who has not seen it in operation. * * * As a means of attaining skill in the use of tools simply, it is beyond question the only commendable system. A good knowledge of the nature, special characteristics, and uses of the tools of any

art being thus taught, the next step, it would seem evident, must be the acquirement of some useful knowledge of the proper and best methods of application of this skill. This can be obtained by an extension of the same general system to a very considerable and useful extent, and, so far as this is possible, there can hardly be any question that this is the best course to take. But this division of the work of instruction demands vastly more than the familiarizing of the student with certain standard and stereotyped methods of forming parts and assembling machines. It demands such variety of work as will give the young man some idea of the thousand difficulties and problems arising in actual practice and in the course of a regular business. Such practice and instruction can not well be given, ordinarily, by deliberately planned exercises, beyond a certain and somewhat limited extent, and the experiences of a manufacturing establishment do, I think, more generally confer upon the novice that kind of knowledge and readiness in adapting himself to circumstances. In fact, it is the habit of promptly meeting emergencies and of inventing and of perceiving on the instant just what is needed to meet unexpected and exceptional demands upon the skill and intelligence of the learner, that actual shop life and practice gives which constitutes its special value in the development of the young mechanic. I also think that the life of the young man in the shop, in the atmosphere of real life which he finds there, must in all cases prove a very valuable incentive to industry, and a good spirit of work and thought. Nothing so greatly stimulates a boy as to be able to feel that he is taking part in a man's work, and doing something which will have a real and immediate practical outcome. It has always seemed to me that if these two methods can be combined, either by synchronous or by successive practice, the result must have a maximum value. * * * I can see a possibility of the two being made to work together. * * * But if the attempt is made to effect this combination, the primary object must be instruction and not the making of money. * * * I should in every case, however, insist upon the preliminary training by systematic performance of carefully planned exercises to such an extent that the student should have acquired a good knowledge of the use of tools of all the familiar kinds in regular use in the principal trades which underlie the work of the engineer."

The equipment of the carpenter shop consists of 14 wood lathes, 16 benches, sets of small tools for 20 students, a combination buzz saw, jig saw, pony planer, molding machine, and mortiser; 2,400 square feet of floor space.

The equipment of the blacksmith shop consists of 8 forges, anvils, tongs, fullers, flatters, swages, swage block, and cone block; 400 square feet of floor space.

The equipment of the foundry consists of a small brass furnace, 4 molders' benches, and small tools and flasks for brass molding and casting; 1,300 square feet of floor space.

The equipment of the machine shop consists of 6 engine lathes from 10 to 20 inches swing and from 4 to 12 feet length of bed, 2 speed lathes, 2 emery grinders, 25-inch back-gear drill press, 18-inch plain drill press, Brainerd universal milling machine, Browne & Sharpe No. 1 universal grinding machine, 24 by 24 inch by 6 feet planer, pipe tools and machines up to 4 inches, a good assortment of small tools in the tool room, and vises and benches for 20 students; 2,800 square feet of floor space.

There are at present about 80 students of all classes taking shopwork.

TECHNICAL EDUCATION.

By C. W. HALL, of *Minnesota*.

GENTLEMEN OF THE SECTION OF MECHANIC ARTS: As we look over the field of technical education and note the progress that has been made, we can see strong reasons for the creation of the Section of Mechanic Arts in this Association. We certainly see the vast amount of work before us as individual educators and as an organization; and we see it even more clearly than we see the work already accomplished in the line of preparation for professional pursuits. Before us is a long stretch of

possible progress, while behind lies the kaleidoscope of many minds working along different lines to reach the vantage ground of present things. We can not now discuss the three time phases of the subject; the past is a heterogeneous mass of mingled efforts and accomplishments and the future is as yet scarcely outlined in its trend. Let us therefore take a look at the present, weigh some things within our reach of an educational kind, and estimate, so far as we are able, their bearings on the future of this Association.

The institution of this section—Mechanic Arts—was a significant thing for the Association to do. It is doubly significant for having been instituted in a Southern city and through the persuasive efforts of a Southern college president.* “Tools and the man,” as Carlyle put it, is to be henceforth the epic of the South; we all want it to be so, and from every quarter we will take up the cry.

Technical education, as we use the word, means agricultural education as well as education for mechanical pursuits, such as railroad building, mining, or chemical manufactures. Plainly, the development of education along this line sprang from the competition of men. Large numbers occupied in any line prompt many to attain excellence. Unity of effort along a definite plan of work is secured only after long and too often discouraging trial. Such has been the history of agricultural education in America, and such was its history in Germany, France, and England.

The two steps that competition invariably prompts are: (1) Development of a broader market ground and (2) diminution of the cost of production. The former has been secured in every age through caravans crossing deserts, ships plowing unknown seas, and military conquests. The latter is attained by starving workmen and artisans and perfecting methods and processes. In the former lie those incentives to heroism and daring which make manhood noble and mark with sharp definition the patience, fortitude, and endurance of the highest types of human plans and achievements. In the latter step there is a constant calling into play of high ability and inventive genius through a constant consolidation of energy. Here, too, lies the mainspring of unrest and industrial disease. The conditions of this unrest lie deep. The train of evils and calamities befalling society is sure to be a long one before the end—a perfect adjustment of wants to possibilities—is attained. We are not to be discouraged; the development of the moral sense in mankind keeps full pace with the advancement of the knowledge of his material environment.

We can not here enter into the history of those educational institutions where agriculture and the mechanic arts have been taught. While a beginning had been made in both classes of schools long before the passage of the Morrill bill, the extension of aid under that bill to the several States was a wonderful impulse to educational activity. Indeed, let me right here emphasize the fact that interest in such education had already taken root on this side of the sea, and this interest was the impulse which led Senator Morrill and others to work all the years from Buchanan’s administration until 1862 to secure the passage of this beneficent law. This, like all other successful legislation, was built upon the sound sense and capacity of the people, and thus we see a reason for the high success of these so-called land-grant schools and all others of related character. Their work appeals to the strong good sense of the people and the people patronize them; legislatures appropriate State aid for their maintenance and the wealthy contribute generously their private fortunes to endow them. The schools in turn are adopting the advice of the pedagogue of two hundred years ago; they are accommodating their studies to the present state of our manners and are studying those things which are of use in the world rather than wasting their energies in the vain endeavor to conform the world to the order of their studies. President Johnston, of Tulane University, told us a year ago that the object of a university is to open the door of the mind; to throw the win-

* President James K. Patterson, of the State College of Kentucky, was the earnest mover in the action.

dows of the soul wide open to receive all the inspiring thoughts of the time. Looking into nature in the spirit of research is the highest object of a liberal training. To reach nature we must use the methods and the tools of our every-day work, our senses sharpened that nothing in the shape of a fact or a phenomenon escape use and our hands so skillful that they will obey the desires and thoughts of our minds even before the command of the will be given them to follow.

Having, then, that scientific spirit which is now permeating the intellectual processes of civilized mankind; having founded schools which are characteristic of the times; and resting in the fact that the character of the English-speaking race is prone to consecutive action, that sudden revolutions are contrary to its spirit—we then have all the necessary conditions for a vigorous and long-lived system of education which, in all lines, shall be and become of the highest practical value and usefulness. It shall make engineers, and not merely workmen; generals in the great army of the employed, and not merely officers of the line and the rank and file. A technical education means much more to-day than in 1862. Think what the science of agriculture was at that time; societies for the promotion of agriculture had been established in this country as early as 1784, in which year the Agricultural Society of South Carolina was organized, and Washington had urged improvements in agriculture upon the people, as was shown by his letters to Sir John Sinclair; yet it was not until the eloquence of that genius in chemistry, Justus Liebig, applied his science to the development of better farm crops and more perfect domestic animals and Johnston put into practice as well as into print the results of many experiments in practical farming, that any widespread interest was aroused. So late as 1860 the lectures and experiments of these men constituted the best there was to the science of agriculture. To be sure, the Rothamsted experiments had been begun more than twenty years before Morrill's labors were undertaken; in Germany Albrecht had done noble work and some local results had been secured in America. He who asks why it is that man is so late as the nineteenth century in acquiring his present civilization has food for reflection in the fact that the rise of civilization and the development of agricultural technical education are coincident.

Again, the scientific agriculture of the '60's, viewed in the light of the science of agriculture of to-day, was extremely crude. Even Liebig's knowledge of the chemistry of plant and animal tissues was incomplete. What did he know of sugar manufacture as we saw it one year ago at New Orleans, or of butter and cheese making as we see it to-day in Jackson Park, Chicago, or of methods of planting and harvesting crops as practiced on Minnesota and Dakota farms, or of the preparation of preserved foods of all kinds? To anyone interested in an answer to the foregoing questions, I would point out the difference between Liebig's works on agricultural chemistry and the files of the Experiment Station Record for the past four or five years; and I might mention many other admirable works of authority and reference familiar to every member of this convention. The comparison between the '60's and to-day is still stronger when we turn to the mechanic arts. I have no hesitation in saying that the conception of mechanic arts in Senator Morrill's mind was that understood by us in the term manual training as this work is exemplified in the work of our best high schools. It is simply that training of the hand and eye to enable the workman to use them in unison and secure dexterity in the prosecution of the ordinary arts of every-day life. At that time there were but few schools of high grade for the training of engineers. Those were of a nature to convince the Senator that the people of the United States needed the expenditure of the funds which his bill proposed to set apart for educational purposes. And what was the people of the United States but the great mass of wage-earners like the Senator's constituency in Vermont, and, for that matter, every other Congressional constituency in New England?

Therefore, thirty years ago the term mechanic arts meant what manual training does with us to-day. Agriculture meant a scientific culture of the farm, a careful

and systematic management, far in advance, it may be, of what farmers of that time understood and put into practice; yet it did not comprehend the manufacture of sugar as that business is carried on to-day, nor the multiplication of the chemical establishments we call creameries and cheese factories, nor the perfected method of harvesting our cereal crops.

We have convened for the purpose of conferring together about the ways and means of mechanic arts in the agricultural colleges of America. The first thing that impresses me is the condensed character of the work typified by this Section of Mechanic Arts as compared with that by any other section in the Association. Let me illustrate my meaning:

Two capitalists, A and B, have each a half million dollars to invest in a business. After mature deliberation A decides to become a farmer. He examines localities as to soil, water supply, markets, and climatic conditions, and determines upon "diversified agriculture" as giving the most chances for success and the least ratio of failure. He employs a general manager to lay out his fields, locate his barn and sheds, build the houses for his workmen, and takes general charge of the business. Leaving \$150,000 in the bank for paying the wages of the first season and meeting any contingencies that may arise in the way of crop failures, storms, fires, or disease, he finds himself the possessor of 7,000 acres of good land with plain strong buildings and a fair amount of machinery. He hires a chemist to analyze his soils, determine upon his fertilizers, examine his water supply, and become an expert assistant in all his investigations. Then an agriculturist is found. As he purposes to keep stock, an expert in breeds and methods of stock-raising is secured; a superintendent of his creameries and cheese factories is next called into his employ; then a horticulturist is brought from the best school of horticulture; and finally a gardener is brought who is recommended for his experience in the Government grounds and greenhouses in Washington. All the rest of his employes are common men of sturdy, honest American, Scotch, Scandinavian, and German stock. He has, then, secured seven well educated, scientifically trained agricultural college men; in short, one for each 1,000 acres of his farm. He proceeds with his enterprise and discovers that he has made so wise a choice of an occupation and of men to aid him in it that three out of his five lines of production are highly successful, and on the whole his fortune grows; he soon has a farm of several thousand more acres than at first and a corresponding number of experts to develop his opening lines of agricultural business.

Now let us follow B, who, seeing the manifold uses of iron in railroad building, mining, manufacturing, and building of every sort, decides upon the establishment of a factory for the working of iron. He selects a location and buys 10 acres, ample ground, well situated for his plans, erects his shops, employs his workmen, builds their tenements, secures an additional acre and establishes his home. Instead of extending his operations over 11 square miles, he occupies 11 acres. He finds competition so sharp that he is driven to employ the very best trained talent, and his roll of experts, engineers, superintendents, agents, designers, draftsman, etc., is a score. The development of his business soon demands more capital, and he protects himself against increasing competition by buying an iron mine, erecting a foundry, building a railroad, taking partners into the business, and calling in another score and more of trained men to look after the various details of his flourishing business.

The foregoing illustration serves fairly, as it seems to me, to represent the difference, in the present decade, between the average application of professional knowledge to agriculture and professional technical occupations. We see in sharp contrast the lines of the agricultural and engineering professional schools. Concentrated masses of men involve the sharp competition of the highest grades of professional business.

Permit me to say a word regarding the great mass of workmen under these two capitalists, A and B, who are not specialists, who expend their muscle instead of

their brains in wage-earning. The farmer, probably, I suspect, from the very nature of his occupation, is not skillful in manipulation; sometimes he is a bungler. This is natural enough; the work he does, from its very nature, does not require much skill or care or exactness. The putting of seed into the ground, the killing of weeds, the harvesting, all demand only ordinary treatment. So through generations engaged in such work he has inherited methods and habits. He relies on the mechanics for his tools and all repairs. He can not make a harvester, nor can he even make a pitchfork or a hoe. Indeed, it is not every farmer who can select a hoe constructed according to the best mechanical principles.

But a different condition of things is soon to prevail. The successful farmer of 1900 must be differently equipped from his grandfather of 1850. It has been found that a business to be successful under the sharp competition of to-day must be conducted on a large scale; that is, a vast product turned out with a small proportion of high-priced labor. So, too, with farming. The successful farmer must possess the knowledge of an agriculturist and must add to that the best mechanical capacity, for machines—plowing, cultivating, thrashing, mowing—are essentials in the equipment of the modern farm. Large crops must be carefully cared for. Thus we see that not only must technical schools be built up and developed for the thorough training of men to become engineers, superintendents, and foremen, but manual training and mechanic arts must be developed in our distinctively agricultural colleges. Farmers must be mechanics. The more mechanical farmers will be the more successful ones other attainments being equal.

Too often farmers' boys go to colleges instead of technical schools. They are taught that educated men are lawyers, doctors, clergymen; that engineers grow up beside the level, the lathe, and the engine. They are urged that book farming is poor farming; that the proper training for a farmer is that practical sort gained only on the farm. Yet no wage-earner in the whole wide range of industries is so intelligent as the farmer, who is so slightly under control by his environment, who has higher ambitions for his family of sons and daughters, or who is more patriotic and loyal to his institutions and Government.

Turn now to the community of B. The boy is an artisan, and embryo engineer. This is quite as true in A's community as in B's. In America he inherits a certain natural aptitude for tools; his ancestors conquered nature and her forces quite as much by mechanical ingenuity as by physical strength. Thus the farmer boy, whenever he can, leaves the cultivation of the soil for the more fascinating work of making a cultivator; he leaves the raising of wheat to build a railroad over which to take it to market, or to erect a mill in which to grind it.

The employé of a shop or a mine is a specialist; he develops himself for a certain use in human society in a somewhat more restricted sense than the farmer. Whenever he seeks employment he finds himself examined for strength and endurance, as is the draft horse and the ox. His occupation is the result of a sort of natural selection; he becomes what he is physically fitted for; he draws his pay and takes his place in the community accordingly.

It should be the duty of these schools, founded on the grant which Senator Morrill's wisdom and patient persistence secured, to aid these men. Their families must be placed in improved environment. To be sure, experimental farms and shops and drafting rooms can not be made compulsory; there is not money enough, under that grant even to make them common. But there should be wisdom enough, and far-sightedness and benevolence enough, on the part of college trustees and faculties to encourage to the utmost the development of the mechanic arts in our high schools. Place in every such curriculum in the United States the opportunities to train the eye and hand together, and the average of average artisans and farmers will be vastly heightened. This is not an impossible thing to attain; we must attain it in order to meet the competition which is to environ America in the fast-coming decades.

Let me parenthetically say: Many speak of luxuriance and extravagance as attendants on American life. Let me express the opinion that everything is perfectly

natural; we are no more extravagant, nor wasteful, nor lavish than is nature around us. We have grown up in a perfectly natural way into conditions which have environed the American people since 1607. We could not have been otherwise if we would. Wastefulness is a relative term; what is wasteful when labor is twenty-five cents per day perhaps can well be afforded when labor commands \$2. There every straw of grain must be picked up by women and children; here we could not afford to do such a small thing. Since habits are of slow and persistent growth, so they are given up after a long struggle. The habits of living which we have grown into through generations will not be surrendered in a day, nor within the period of one or several administrations. We must gradually conform to a new environment if we conform at all.

Let me here suggest a duty to officers and instructors in our technical schools, whether they be schools for agriculture or engineering pursuits. It is founded on the experience of the past thirty years. Those institutions are most successful that are closest in touch with the sentiment of their generation. Experience showed centuries ago that a farmer could not raise figs on thistle bushes, and the builder who "stablished not upon a rock" had an uncertain foundation beneath his structure. It is a hard and discouraging task to build an institution of learning in the face of the plain trend of the times. An education is material; it fits young men for contact with material things; it trains them for this world instead of the next; it develops their tastes and aspirations; it impels to a higher plane of living and thus develops a broader and more enjoyable life. That materialism which makes higher and more perfect the home life of the citizen has its advantages, whatever of censure it may receive. We can not expect every State to develop precisely along the same line of educational activity as our own commonwealth is making successful progress. As each community has its own lines of material success so it has its parallel lines of intellectual bias and progress. A community of sugar producers does not desire a farmers' institute devoted to dairying; neither does a community devoted to the manufacture of boots and cloths care for a school to teach assaying and mine engineering; nor an engineering school want its curriculum filled to the close with Latin and Greek. Let us aim, then, to direct our several States along the plain and unmistakable lines of their destiny. Some of us have tastes, or predilections, or prejudices, perhaps, which run counter to such a course; then let us bury such feelings and work for the great cause of the commonwealth and not emphasize the small matter of our own preferences.

I know a State—I have lived in it more than twenty years—where there has been a constant contention against the evident condition of things. I am within bounds in saying that tens of thousands of dollars have been expended in the effort—and I may say it was a vain effort—to keep a course of study and an organization that nobody wanted sufficiently to patronize. It was not because the people of Minnesota were not intelligent enough for such work, but because they could get all the professional training they wanted in a cheaper and more practical way. While this effort was carried on scores of her sons were obliged to go to other States for the education we would not give because the other useless work must be offered. I venture the assertion if we had done the things we ought to have done and not done the thing we ought not to have done, the foundations of higher education and professional training in our State would be far better and more broadly laid than they are to-day. They would have been laid along the trend of our development as a commonwealth. Professional skill and high scientific attainments would be far better grounded in the thoughts and aspirations of our whole people than we see them now. Yes; keep in touch with the times. Encourage the faculties of your colleges always to act as a unit in the advancement of those lines of study and research which are of the highest character and are the best adapted for the advancement of the enterprises peculiar to your State. Then, when your institutions are old, as we speak of old institutions to-day, citizens will look back and laud the prophetic wisdom of the founders.

To bring our reflections to a close: Paraphrasing Prof. Huxley, our schools—schools of agriculture, technology, general science, and classics—exist. Common sense surely suggests that they be made efficient or abolished. We can not accept the alternative of abolition, as that would knock the keystone out of the edifice we have, since 1862, been rearing. Efficiency means a liberal support in means and in energy of administration. Economy does not lie in sparing money but in spending it wisely. So it is desirable that resources, both public and private, be made available and distributed among our schools. The trend of events now compels us, as never before, to look the future squarely in the face. We see the outlines of an industrial struggle far more stupendous and far-reaching than we have hitherto conceived. It will reach every activity of life. No one can escape it except he die. Technical education is that kind of training which will make future Americans excel future foreigners in this industrial struggle just in proportion as present Americans possess superior aptitude and energy to take advantage of surrounding conditions and bend every circumstance to their good.

The scientific spirit is abroad in the land. It is pervading the masses of humanity. It aims at practical, tangible results. The day is far distant when pure science will be the highest aim of our educators and investigators. The more perfect the attainments of the practical men and teachers of this day and generation, the sooner will come the day of highest attainments in the arts and in all the conveniences and accessories of life.

THE MANUAL TRAINING AND THE APPRENTICE SYSTEM.

By C. RUSS RICHARDS, of Nebraska.

One thing that I hope to see taken up by our legislators, and our educators as well, is the problem of the trade school. I believe that our system of education for the mechanical engineer is a most excellent one. The engineering student receives a sufficient amount of shop training to make him familiar with the use of tools and with a good many of the more important shop operations. Our so-called "manual training" schools—whose methods are the same practically as the mechanic-arts schools, but whose ideas are different—are doing an excellent work for the youth of this country. But it is the American trade school which has been sadly neglected.

We can train engineers, or we can teach a boy that he has two eyes and a pair of hands in addition to his brain, but how about the hundreds of thousands of young men who must earn a living and make a place in the world by hard work. Many of these young men have not the ability to become engineers, and, besides, we can not have all engineers and no laborers. The manual training school, pure and simple, does not attempt to teach a trade, and could give them little but the rudiments of any line of work. What, then, will be done with them?

Shall they grow up as unskilled laborers, eking out a miserable existence, doing that which requires no skill or knowledge, and which breaks down any ambition they may ever have had? These are questions of the utmost importance not only to us as educators, but to the General Government as well, for by the number of its skilled artisans can a country's worth be gauged.

As I have before said, the present system of mechanic-arts training and manual training are well nigh perfect for the particular purpose for which they were devised. The mechanical engineer must know the "how and why" of the use of tools, but he may not necessarily be an adept in their use himself, although, if he is, he is much better off.

The manual training schools, while they were not devised for the technical training, are of immense benefit for any person who expects to make a future use of technical training, but for a person who expects to become a tradesman they do not go far enough. The fundamental principles of tool work are thoroughly taught, but it

requires an apprenticeship of some sort before anyone could become a journeyman laborer in whatever branch of work he might select. That is, the mechanic arts or the manual training schools are not and never can be complete enough to educate a tradesman, for any trade or professional school to be complete must combine within itself all the points that will be necessary to the successful following of that trade or profession.

We may say, then, that at present the only way of learning a trade in this country is by an apprenticeship of from three to five years, providing, always, that the boy can secure a place as an apprentice.

Being curious to know the present attitude of prominent machinery builders and manufacturers to the apprentice system and the system of mechanic arts and trade schools, I sent a number of questions to some of our representative firms in this country, bearing directly on this subject. I confess that I was very much surprised at some of the replies. I desire to give as much prominence to the opinions of these men as is possible, although I may not agree with what they say.

My first question was: "Will you take an apprentice in your shop?" To this question I received nearly all replies in the affirmative from the 16 or 17 firms who were kind enough to answer my queries.

Bement, Miles & Co. say: "Yes; we take 3 or 4 apprentices into our shop every month."

The Yale & Towne Manufacturing Company answer that "We formerly took apprentices, but have not for a number of years. Our present practice is to take young men under instruction, paying them moderate wages, increasing yearly, but without obligation to them to remain for any specified time."

Mr. Bole, superintendent of the Westinghouse Machine Company, says: "Not knowing anything, practically, of the old apprentice system, we can not well draw any comparison between that and our present practice. We have no very well-defined system, but we do take apprentices, giving them three years' term of service, paying them \$4, \$5, and \$6 per week during the three years, respectively. If the boy be unusually bright and capable, we encourage him by paying larger wages. We do not attempt to rigidly treat everybody alike in the sense of giving a stupid boy the same consideration or the same wages as the bright boy. Engaged as we are in manufacturing a specialty, it is to our interest to keep a boy on one class of work as long as possible, so that when he becomes proficient we continue to derive the advantage from his proficiency. Of course, the average apprentice is taught to run a lathe, planer, milling machine, and to do such work as drilling and boring. We have not employed apprentices for fitting work or bench work of any sort, but use older mechanics for such purposes.

Mr. Grimes, superintendent of Williams, White & Co., replies as follows: "Yes, if he agrees to stay five years and work all around the shop."

Mr. F. A. Pratt, of the Pratt & Whitney Company, says: "We do take apprentices, and have now 105, with a large number of applications ahead. We take boys from 16 to 20 for four years, and bind them. We have our selection from a large number of names always on our books. We choose those who have parents who are responsible, and select them by their mental and physical qualifications, and have very little trouble in keeping such boys their full term. The bound apprentice gets a discipline that can not otherwise be obtained."

Chandler & Taylor say: "We take apprentices in our shops, that is, they are called such, but in reality they do not learn the full machinist's trade. They simply go with the trade far enough to become expert as lathe, planer, or machine-tool hands."

J. W. Anderson, superintendent of the Moline Wagon Works, answers: "Yes, I would take an apprentice if I was conducting a machine shop as a business, employing 4 or more men, as in a shop of this kind there is work enough to employ a novice and give him a chance to gradually acquire the handicraft part of the trade.

But as I am at present situated, managing a large factory, using machinery, but not building it for sale, keeping 2 to 4 machinists to keep the factory machinery in repair and make special tools, an apprentice would not be available. This, I think, is the position of most manufacturers whose business is not building machinery.

Prof. Sweet says: "We do have and always have had about half as many apprentices in our machine shop as workmen."

Question 2 was: "Do you believe that the average young man can, as an apprentice, secure the best general knowledge of practical mechanics (I refer to the present time)?"

The J. A. Fay & Egan Company reply that "The average young man can, as an apprentice, secure a good, thorough knowledge of practical mechanics, but only in one branch at a time?"

William Sellers & Co. say that "An apprentice must go to his trade at about 16 years of age, and hence can not have much of a technical education. Apart from that fact, he has an opportunity to gain an excellent knowledge of practical mechanics."

Prof. Sweet answers: "No; even in our shop, which is above the average, I do not think it is a good place to learn the machinist's trade. He gets very little knowledge of anything but steam engines, and that of but one kind."

Mr. Grimes replies: "As a mechanical engineer, no."

Chandler & Taylor say: "As trade is now running everything is drifting into specialties, and therefore an apprentice is an apprentice for a specialist."

The Hendey Machine Company say: "With our system, yes. We teach them all parts of the work."

J. W. Anderson answers: "No, I do not; for, while an apprentice in a machine shop may acquire the manual dexterity that will enable him to do good work, he lacks the knowledge of the underlying principles which govern machine construction. A man with that kind of training does well as long as he has a guiding hand to direct him, but when thrown upon his own resources he usually makes a signal failure. Of course, there are exceptionally bright and ambitious men who will rise in spite of their lack of proper training."

Mr. Pratt replies that "The machinist is not, as a rule, the drudge he formerly was. The milling machine, planer, grinding machine, etc., take the place of hard drudging, and the boy learns to construct and run these machines in place of chipping and filing, as formerly. In our work he has a few months (if he desires and has a fair education and natural talent for it) in the drafting room."

The Westinghouse Machine Company say: "It is difficult to answer this question in a few words. While there is no royal road to learning in the machine business, yet some boys find the road much easier than others. It is doubtless true in a manufacturing establishment such as our own (when special machinery is used, and where nearly all the planning of machine operations is done by the foreman, and the men simply operatives), that there is not the same opportunity for a wide experience as in jobbing shops, when the men do a little of everything, and oftentimes do it as they please. On the other hand, the standard of workmanship in a manufacturing establishment is generally higher; and if graduates of such an institution can not do as many things as graduates of the 'old line' shops, they can generally do what they can do both quicker and better."

The Yale & Towne Manufacturing Company say: "Under existing conditions, in most lines of industry, it is not easy for young men to become apprentices. On the other hand, it is not difficult for them usually to obtain opportunity to become practical mechanics, providing they have fair aptitude and diligence."

Bement, Miles & Co. say: "Most of our best mechanics are those who have served their apprenticeship with us, and the others have all served apprenticeships in some similar establishment. We believe it is the best way to get a knowledge of practical mechanics."

Brown & Sharp Manufacturing Company reply: "We do not believe that the average young man can, as an apprentice, secure the best knowledge of practical mechanics at the present time."

In my third question I ask directly, "Do you believe that the so-called manual training or trade schools give a good foundation for a person expecting to become a machinist?"

Mr. J. H. Springer, superintendent of Frazier & Chalmers, replies emphatically, "*I do not.*"

Mr. Robert C. McKinney, of the Niles Tool Works, answers this question as follows: "The average apprentice starts in with very little education, and many of them with little ambition, and therefore do not become very skilled or expert. An education at a manual training or trade school, gives a young man a good foundation to start on, and applying the knowledge there obtained, he can, in a shop where he is brought in contact with the practical business, make a success of it, and succeed better and be advanced more rapidly than one commencing his trade without these advantages."

Prof. Sweet says: "I have had no opportunity to form an opinion of what is really being done. Do not believe there is any use in stopping short and simply give the boy a foundation, but go on and make him a machinist. That is, a better general machinist that can be made in any shop during an apprenticeship; of course, assuming that funds are supplied for fitting up the plant."

Bement, Miles & Co. reply: "Yes, if the person goes to the training school before entering into a mechanical establishment, it would certainly give him an advantage over one who had not studied the subject at all. We think it would be a better system if boys could learn the practical side at an early age and the theoretical side afterwards. If both could be learned together it would be still better, and this, we understand, the training school attempts to accomplish. They have not been established long enough as yet for their success to be demonstrated by the result."

The Westinghouse Company answer: "We do not know by any personal experience as to the benefit derived from manual training schools, but believe that they ought to have a beneficial effect; and, while it will not take the place of a practical apprenticeship, it is certainly an assistance to any boy who wishes to become a machinist afterwards. In a manufacturing establishment the chief end of the employment of labor is the making of money; therefore, more attention is paid to getting out a product than to the education of the operative for his own advantage."

William Sellers & Co. say that "If the manual training schools have no automatic machinery, and merely teach the boys how to use their eyes and hands, then there is no better foundation for an apprentice, and we seek boys who have had this training."

Mr. Grimes replies: "Yes, so long as the student realizes that it is only a foundation."

The J. A. Fay & Egan Company answer: "We believe that the so-called manual training or technical schools are very advantageous to a person expecting to become a machinist. We have had some of that class in our employ and they always take a leading part and become much more proficient in mechanics than the average boy we take in to learn a trade. In other words, this class of boys is just a little better educated than the other, and the practical training they receive in a technical school gives them a great advantage, and they advance in a shop like ours much more rapidly than others."

In answer to this question J. W. Anderson says: "Yes; they not only teach correct and approved methods of doing work, but the theoretical knowledge gained is invaluable. A thorough knowledge of drafting is also of great importance, but seldom learned by an apprentice."

Brown & Sharp answer: "We consider the manual training or trade schools to be a help and good as far as they go."

Chandler & Taylor think that "Manual training or trade schools most certainly give a foundation to a young man expecting to learn a trade, whether it be a

machinist, founder, or pattern-maker, but in our opinion a manual training is only a foundation."

Other replies to this question were practically the same as those given above. The next question I asked was: "Is not the vast amount of special machinery now built detrimental to the apprentice system?"

From Mr. Pratt I got this answer: "The vast amount of special machinery now built takes the place of drudgery, and places the machinist on a higher plane. If the apprentice is in a machine-tool works, certainly his practice in designing and building these special machines is so much above that which the writer received fifty years ago that there is no room for argument. Yet the apprentice in any shop will get sufficient practice with cold chisel and file to be of service to him when these special tools are not available."

The Putnam Machine Company say: "Yes."

The Yale & Towne Company answer: "Undoubtedly the continually increasing use of special machinery militates against the old apprentice system, which latter is likely to practically disappear in this country. On the other hand the use of such machinery and the ease with which an unskilled person can become skilled in the use of some one machine enables vast numbers of persons to find better employment than they otherwise could."

Chandler & Taylor reply that "The specialization of work in the various lines would of course destroy in a great measure the old apprentice system."

Mr. Anderson answers: "Yes; for the reason that an apprentice is usually kept on one part of the work, and has no opportunity to become a general machinist. He may be a skilled lathe man, but if so, that is as far as his knowledge goes. This condition is similar with other parts of the work."

The Niles Tool Works answer: "To a certain extent, yes."

Prof. Sweet says: "Yes, as a general thing."

Bement, Miles & Co. reply as follows: "No, not in the least. There are plenty of establishments where apprentices can obtain a complete mechanical education. Mechanical engineering is becoming divided into branches, and no one can be expected to know them all. The apprentice must select the branch he desires to follow, whether it be marine, locomotive, land engine, electrics, machine tools, etc."

The Westinghouse Company think that "As to the special machinery it has its own lessons. It does not throw any obstacles in the way of a bright boy making a good man of himself. It rather teaches him that the chief aim of a mechanic is not to put in time and draw wages by the hour, but to produce some desired result with the least expenditure of time, labor, and money."

William Sellers & Co. believe that "The increased accuracy and expedition in methods of manufacture required by modern practice offset the disadvantages suggested."

Mr. Grimes says: "No; for the apprentice must fit himself to design, build, and repair such machines."

Brown & Sharp answer: "We do not consider the special machinery now in use detrimental to the apprentice system. It gives a different kind of knowledge than that obtained under the old system, but a kind that we think is more suitable for modern requirements."

Question 5 is practically the same as question 4, only in a little different form: "Does not the sharp competition in the manufacturing business cause the boy as an apprentice to be practically shut out from a general knowledge of the machinist's trade?"

Mr. Anderson says: "Yes; especially in what are known as manufacturing machine shops, for the reason given in question 4. The smaller jobbing shops are approximately the only places where an apprentice can get a general training in the machinist's trade, and then usually only the manual part of it."

Chandler & Taylor reply that "The sharp competition in manufacturing has

expanded the machinist's trade to such an extent that the average boy does not desire to make himself familiar with the entire trade."

The Putnam Machine Company, answer that "Yes. In a large number of shops manufacturers desire to get all the profit possible out of a boy by having him do one particular kind of work all the time."

Mr. Pratt believes that "the sharp competition compels the invention of new and special machines and processes in which an intelligent boy becomes interested and will try his hand in such improvements."

The Niles Tool Works say: "To a certain extent, yes. An apprentice is more apt to be taught only one part of a trade instead of a general knowledge itself."

Prof. Sweet replies: "If not, then it is the fault of the instructors, growing out of the almost irresistible disposition to teach the theory and principles and then try and put it in practice, instead of keeping the hand work ahead all the time. It is the machinist's business to *learn to do*; it is the engineer's and foreman's business to learn to know and to explain *why*."

The Westinghouse Company believe that "sharp competition in the manufacturing business should conduce to the best methods in manufacturing, and a sharp boy should not be slow to distinguish as between the shop which can do work cheaply and well and the shop which can not do it cheaply and well. There is an object lesson in this for the boy almost as important as learning his trade."

Wm. Sellers & Co. reply that "many establishments have ceased to take apprentices partly from the cause suggested, but the shops which continue to take them still turn out excellent workmen."

Mr. Grimes answers: "Yes, if the apprentice becomes simply a cheap attendant upon a special tool. This should be arranged in the agreement to serve as an apprentice."

Brown & Sharpe's answer is: "We do not consider that sharp competition in the manufacturing business causes a boy to be shut out from a general knowledge of the machinist's trade. On the contrary, it gives him an opportunity to observe methods and economies which never would be thought of or practiced were it not for sharp competition."

The J. A. Fay & Egan Company answer: "The sharp competition in the manufacturing business causes most factories to use a boy or an apprentice on one class of work. In other words, we put a boy on a lathe and he generally stays there, or we put him on a planer and he stays there, or we put him on a vise and he stays there, and so on; but we have a great many boys who learn all three branches in the same time that one boy learns one of them, and whenever a boy displays any ability of that class we generally move him around and give him a much better opportunity of perfecting himself."

In my last question, I ask directly: "In your opinion is the present system of manual training and trade schools a practical success?"

Mr. Springer underscores his "No."

The J. A. Fay & Egan Company say: "We really believe that the system of manual training and trade schools is a practical success. We have seen quite a number of good mechanics turned out of them, and all they wanted was just a little practical work in a good first-class shop to make them first-class mechanics. We believe that technical schools are doing a great work, especially in the South and West, where shops of our kind are not so plentiful, and it gives the American boy a chance to learn a trade that he could not obtain in any machine shop."

Brown & Sharp reply that "The manual training schools should not be considered as taking the place of the apprentice system, but should be supplemented by an apprenticeship."

Chandler & Taylor say: "In our opinion the present system of manual training in the trade schools is a practical success so far as it goes, but not with the view of the student learning any practical trade, but rather in the line of developing his judgment and the skill of his hands."

From the Putnam Machine Company: "Yes."

Bement, Miles & Co. answer: "It is too early as yet to decide. Every subject should be better understood when special attention is devoted to it, and, therefore, we suppose the manual training schools will have a good effect by causing their subjects to be more intelligently studied. We think it is still open to question whether, if a boy were kept at a good school until 17, and then apprenticed in a good establishment, he would make a better engineer than if he went through a training school. Our Mr. Miles is of the opinion that the only way to make a good engineer is to cultivate his imagination, as the creative or inventive faculty."

Mr. Pratt replies to this question: "The manual training school is a success, more or less, depending upon its management, but it will not take the place of a regular apprenticeship, when productions must be sold at a profit in competition with others. You might as well say that railroads spoiled the old stage coach business and the sale of horses, that the bicycle saved shoe leather and hurt the shoemakers and the leather trade, as to say that labor-saving machinery is making the machinist's trade less desirable. Do all we can in the direction of education and improvement, and there will still be enough hand work and plenty of mechanics who are fit for nothing else but such drudgery."

Such is a synopsis of the replies I have received from some of the most successful firms in the United States. I believe that in a majority of the replies you can secure arguments in favor of the school system of training a tradesman, as against the apprentice system, although in a number of cases the evident intention of the writer was to condemn the school training, or if not to condemn it, to withhold all praise of the system.

We can not but agree that the apprentice system is a good one in some shops and bad in others; in some shops the apprentice is given every possible chance, in others he is given none, practically. But no matter how conscientious a firm may be as regards their apprentices the system can not give good results without a great effort on the part of the apprentice. Although in many of the replies to my questions it is claimed that competition in business does not affect the apprentice, I really can not see how it could help placing difficulties in the way of obtaining a trade, because the cost of production must be reduced to the lowest possible point, and every employé must exert himself to the utmost for the benefit of his employer. How, then, can it be possible to spare valuable time for the instruction of the novice? How will it be possible to allow a beginner to spoil material (and every beginner will spoil a certain amount of stock) when every possible economy must be practiced if the business is made most successful.

It is the necessity of cheapening production that has called forth all the skill of inventors to produce special machines to do the work. These machines cheapen and facilitate production in every way, and we would not go back to the old drudgery, as Mr. Pratt calls it, even if we could, although I am sure that these machines make it more difficult for an apprentice to secure a trade.

A number of manufacturers in answering my questions admit that a majority of boys will be put on a certain line of work, at a certain machine, and in all probability they stay there, becoming in time a mere machine themselves, a part of the one they operate. Of course there is some benefit to the bright boy in seeing new machinery built, but not much unless he understands the details of the machine, and helps in assembling the parts to produce the finished whole. If the apprentice's connection with a new machine consists merely in turning up a piece to a given size and shape, or in planing down a piece as directed by the foreman, he would receive no more benefit from it than he would from turning or planing only comparatively simple work.

Of course, there are firms who endeavor to the best of their ability to give the apprentice a proper training, and with such firms the apprentice can secure a thorough knowledge of his trade. I understand that there are things that an apprentice

will learn that could probably never be fully incorporated into a school training. The apprentice must feel a certain sense of responsibility that is ordinarily lacking in the school boy. On the other hand, when thrown upon his own resources the school-trained boy, having been taught to analyze things and to understand the "why" as well as the "how," will be the better able to assume any responsibility, for, if I may say it, the responsibility of the apprentice is more one of fear than anything else.

School methods are such as to impart more knowledge in a given time than any other, for each operation is carefully explained by the instructor, and the reason for each step given, so that the novice can see why a certain thing is done in a certain way, instead of being merely shown how to do the work, and then left to discover reasons as best he can. If a mistake is made it will be corrected by the instructor without making the boy feel that he has committed some crime.

In the school there is also given a thorough knowledge of drafting, which, as Prof. Unwin aptly remarks, is a kind of "written language" for the designer and the machinist. There are some establishments that give their apprentices a chance to learn something about drafting, but they are rare indeed. The foreman usually lays out the work to be done, so there is but little chance even to pick up a knowledge of this very important work.

Aside from the technical work, the boy will be better educated in the school and will make a broader man in consequence. Having a better education than the apprentice-made man, he must advance more rapidly in whatever line of work he may choose.

Believing as I do that the school system of technical training is a success, and that it could be made equally successful in giving instruction to the artisan, I would like to see trade schools organized by the different States. To be eminently successful they must necessarily be kept separate from any other school of collegiate rank, and at all times retain their primary aim of turning out artisans. It would be an absolute impossibility to successfully conduct such a school in connection with a college or a university; for, as Francis A. Walker says, in replying to an article on "Relations of academic and technical instruction," "Young men do not greatly care to go to schools where they are not respected equally with the best; where all the praise and all the prizes go to others; where the stained fingers and rough clothes of the laboratory mark them as belonging to a class less distinguished than students of classics and philosophy."

The school should include instruction in the following trades: The machinist's, the pattern-maker's, the blacksmith's, the cabinetmaker's, the tinner's, the molder's, the plumber's, and the steamfitter's. In certain sections of the country other trades of special importance in those localities should also be added. The practical instruction should begin with a course in the shop similar to that now given in our best technical schools, so that the student would obtain a general knowledge of tools and their use, and thus get a better knowledge of the relations between his own and other trades. After this general tool work, let the student select the trade in which he is most interested, and make a specialty of that particular work. Every detail of the trade should be carefully taught, so that the student will be, in truth, a master of his craft when he completes his course.

Particular stress should be laid upon the scientific principles underlying each trade, and every possible means taken to make the student thoroughly interested in everything he does.

In a school of this sort, after teaching the elementary principles of the work, the most successful policy would be to manufacture articles of a commercial value, wherever possible, and use the proceeds from the sale of such articles for the purchase of new materials. If the proceeds should exceed the expenditures, the balance might be used for the support of indigent students.

The other work of the school should include a thorough course in mechanical drawing, mathematics through trigonometry, a good knowledge of English, some work in history, and physics. In other words, give a good liberal education in addition to the practical work, the whole course extending through three or possibly four years.

As teachers of the trades, well-educated men who have been foremen would be best fitted for the work. If the instructors in all the branches could be men of technical education the school would be the better for it, for the one central idea could then be best carried out.

In suggesting this system of trade schools, I can realize that it would be most successful in the Southern and Western States, where there are but few shops and factories as yet, and where, consequently, it is difficult to learn a trade. Even in the Eastern and Central States, where there are better chances to learn a trade as an apprentice, a school of this sort would undoubtedly be successful, for ordinarily the applicants for apprenticeships are more numerous than are the places for them.

A school of this sort would be a success; it would educate and make skilled workmen of a class that would otherwise receive but little education; it would interest a man in his work for his work's sake, and he would consequently strive to improve himself and make himself better fitted to do his work. New means of enjoyment and recreation would be opened to him, and, even though he always remained an artisan, his life would rise above the mechanical existence of the ignorant laborer.

MECHANICAL DRAWING IN TECHNICAL SCHOOLS.

J. J. FLATHER, of *Indiana*.

The comparatively recent rise of engineering as a profession and its rapid growth have called into existence numerous technical schools for the education of the future engineer, which have been organized and oftentimes controlled by those who have derived their ideas of proper methods of professional training from inherited or acquired experience in teaching the old or "learned professions"—theology, medicine, and law.

In the learned professions intellectual development is the primary thought, whereas in the education of the engineer the aim is to so train the student that he may have a thorough conception of the principles upon which the profession is based, and such practice in applying these principles as will best enable him to succeed in whatever branch of engineering he may enter after leaving college.

Whatever intellectual development the student may acquire is a result of the process, not the direct aim.

Considering the newness of engineering education, it is not surprising that features exist and are carried out in the curricula of some of our technical schools which only in a measure attain the desired end.

Owing to the comparatively short time they have been in use these features have not been generally recognized, or, if recognized, the adherents of the old school have opposed any change.

Another reason for their existence is the fact that each new school is equipped with instructors and professors who usually adopt the methods they were taught; hence we see in certain lines a general similarity of instruction which, although it may promote the knowledge of the student and enlarge his mental capacity, does not best subserve his ultimate advancement.

While we recognize that the subject of engineering education is not sufficiently old to be crystallized into a definite form, and while we further recognize the advisability of having different kinds of engineering schools—some having departments for shop practice and others providing courses where manual training is omitted—yet there are many subjects which are commonly included in all courses for engineering students, prominent among which is mechanical drawing.

This subject, as frequently taught, does not give the student that training, of which we have already spoken, which will enable him to make the greatest advancement after graduation.

The actual system of projection as taught by many professors is opposed to shop practice, and the student so taught, when he enters upon the duties of his profession, has not only to learn the shop methods, but he must forget much of what he has previously learned.

As drawing is the language of the engineer, it is of the greatest importance that the student be properly taught to express himself, and that his methods conform to those in vogue among practical men. You are doubtless familiar with Chordal's boy Joe, who wrote 22 pages of legal cap to explain a detail drawing. A drawing which requires explanation does not fulfill its mission. A draftsman can not always be at hand to interpret his drawing, nor should he be. Drawings for use in the shop, right at the draftsman's hand, should be so complete and self-explanatory that a properly skilled workman a thousand miles away could execute the work without a word of descriptive matter.

The machine-shop drawing is simply a memorandum, showing what is to be produced. It is necessarily an illustrated memorandum, and to be perfect it should answer all questions which a workman can reasonably ask in regard to the work.

It is not necessary to have a finely-finished drawing; in fact, shop drawings should not be finely finished. A clear representation of the piece with good heavy lines and distinct dimensions, even if drawn freehand, is to be preferred for shop use to a highly finished fine-line drawing which the college graduate is so prone to turn out when he first enters a drafting room.

As freehand sketches enter largely into the work of the engineer the importance of teaching freehand drawing can not be overestimated; and although it may not be generally considered as mechanical drawing, yet its common use in the drawing room and shop entitles it to be properly classed under this general head. Moreover, in this connection it is most frequently used to give form to an object in a manner similar to that employed in mechanical drawing. In this respect it differs from artistic sketching, which gives a general representation of the prominent features of an object or scene.

Freehand drawing is a wonderful aid in the cultivation of the observing powers, and practically the first step in drawing is to learn to see accurately. One of the foremost American engineers of the present day, whose name you would recognize were it mentioned, has so cultivated this power of observation that he has in several instances comprehended the details and dimensions of a machine so completely by inspection that he has been able to make working drawings and duplicate the machine without making a single measurement or sketch.

The beginner will soon recognize that the untrained eyesight is untrustworthy, and when this is realized the importance of keen observation becomes apparent. Erroneous conceptions which the untrained eye will cause the hand to execute may be corrected by intelligent practice, and for this purpose the student should early be given a course in object drawing.

His first work should consist of exercises in drawing straight parallel equidistant lines, both horizontal and vertical; then should follow exercises with curved lines and circles in the flat, after which the student should be given a few examples in shading with the pencil from copy. At this time he may be given simple objects and machines to sketch, and the relation of the several views of a mechanical drawing to the object represented and to each other should be early impressed upon his mind. For this purpose actual machine pieces and combinations will be found of greater value than geometrical forms or wooden models, for a machine piece not only presents a greater range in offering several views which may differ in some respect, but it is the general experience that a boy takes to such drawing more readily and with greater interest.

As the work progresses the student should take measurements from the objects to be represented and the sketch should be dimensioned according to the conventional shop methods.

Another advantage in employing actual machine parts is thus obtained, for where a measurement is a little above or below a standard size the student must exercise his judgment in deciding upon the suitable dimension to adopt—a point which the draftsman must learn sooner or later.

A valuable exercise in freehand drawing is given by introducing, from time to time, memory sketches in which the student has to draw a given piece after an examination of the part. Time sketches are also an aid in teaching this work and should be alternated with the memory sketches.

An aid to the proper disposition of the views in a mechanical drawing is the conception (proposed by Mr. Sellers) that the object is surrounded by a glass case hinged on all sides and so constructed that it can be opened out flat as shown in the sketch on blackboard. By assuming this case to be placed over the object to be drawn, the top view will be seen by looking on top of the object; the front view will be seen from the front; and the right and left views to the right and left of the front view respectively. By tracing the outlines of these several views upon the glass and opening out the case the several views will be placed as follows: The top view will be shown on top, the front view will appear immediately under the top view, and the end views will be drawn to the right and left of the front view and in line with the latter, so that the position of the drawing indicates the view taken. This disposition of the views has so many practical advantages that it is employed almost universally in the shops.

Exercises in lettering should begin with the first work in freehand drawing and should be continued throughout the entire course. There is nothing which discounts a drawing so much as poor lettering, and there is scarcely one graduate in twenty who, upon leaving college, can print his own name rapidly so it will look well. A part of this fault lies with the teacher, who must bear constantly in mind that the old proverb, *poeta nascitur non fit*, does not apply to lettering. The man who would letter rapidly and neatly must acquire the ability by continued practice; he is seldom born with a pen in his hand. The student should be given one or two simple forms of letter which can be made rapidly, and all his subsequent work should be confined to these simple forms. It is folly to attempt fancy lettering, and time spent on such work is thrown away, for no office draftsman could spend the time necessary to make such letters. A plain block letter for titles and a running law Italic, a plain Roman, or a style of round writing, are the only forms which the student should try to master.

The writer has adopted a plan which is productive of good results and one which might be carried still further to advantage. It is that in all exercise work and in weekly tests all subject headings, with name and date, must be neatly printed off-hand. This gives continual practice in addition to that obtained in the drawing room, and it is found that the men gradually acquire a fair degree of rapidity and style.

In this groundwork the principles of projection should be thoroughly inculcated in the mind of the student, as much of his after success and advancement depends upon his thorough knowledge of these elements.

The time spent on this freehand work is, in most colleges, too short to accomplish much good. It is the writer's opinion that the average student is in a better condition to enter upon the more advanced work of drawing and machine design by a thorough course in freehand, and that ultimately he accomplishes much more than if such time were devoted to instrumental work. From four to eight hours per week may be advantageously devoted to this work throughout the first term of freshman year.

At this time instrumental work should be taken up, and right here much valuable time is wasted in elementary exercises in line work, consisting of the construction of geometrical diagrams arranged with a view to securing facility and accuracy in the use of instruments.

Why not start the student upon projection drawing at once and let him acquire facility of execution at the same time he is obtaining practice in projection? His experience in freehand sketching has taught him the principles of projection and his subsequent work with the T-square and compass should be in the nature of a development. Let the student then be given machine pieces and simple machines suited to the capacity of the individual from which he must make working drawings. By the use of notes, blackboard, and elbow work, let him know what constitutes a good working drawing and let him use the ordinary conventional shop methods of representation. Have good examples of shop drawings so disposed in the drawing room that he may refer to them for comparison and for such minor details as are necessary to make a proper drawing. Above all let the student assume that his drawing is going into the shop to be worked from, and treated in all respects with no more care than any other working drawing. If there is any error or misunderstanding the draftsman alone is responsible; if the lines and figures become indistinct with shop use, it shows they should have been made heavier; if verbal or written explanations (other than the customary notes which appertain to a working drawing) are necessary, it shows an incomplete drawing; and it is the province of the instructor to see that these objects are attained. In this work the character of the examples may be very properly differentiated for the several departments of engineering.

In the present discussion of the subject we shall confine ourselves to such work as would be suitable for mechanical or electrical engineers.

Tracing and blue printing should be taken up at this time and the work of the term completed by a series of graded exercises in isometric drawing, line shading, and tinting. To carry this work through successfully will require from six to ten hours per week for twenty-four weeks.

At the beginning of sophomore year a short course should be given the student in descriptive geometry, including shades and shadows. The time devoted to this subject may vary from five to eight hours per week for sixteen weeks, two hours of this time being given to recitation-room work. Upon the conclusion of this subject our student should be given over a line of work preparatory to machine design. For lack of a better name we shall call this work the "mechanism of machinery." Its object is to study the nature, proportions, construction, and analysis of existing machines, and may be taught by means of lectures, inspection of the actual machine, and drawing-room exercises. Where possible the machine should be taken apart by the students and its several parts sketched. Visits of inspection to manufacturing works, in which the students may watch and note the more important methods of construction, constitute a part of this work. In the various machines inspected, the methods of oiling and adjustment, provision for taking up wear, extent of wearing surfaces, different metals used and reasons therefor, should not only be carefully pointed out to the student, but he should be taught to observe these features himself. By noting at the same time the widths of belt used and the speeds at which the machines are run, also the character and quantity of work turned out, the student is not only preparing himself for the immediate work of machine design, but he is acquiring habits of observation which will be an advantage to him throughout his entire career. The ability to get at the true inwardness of a machine by observation and analysis from point to point is not usually possessed by the untrained engineer.

Lectures on methods of handling and turning out work in machine shops and other works constitute a valuable feature of this subject, for even with the best of college shops and methods of instruction the student obtains but a limited knowledge of shop practice.

The object of the lecturer on this subject should be to point out ways and means, and to indicate where designs are defective; where they may be improved; where and why other proportions should be used; how parts may be changed so they may be constructed more cheaply; in short, as far as possible, in the limited time at his disposal, his object is to teach the more important principles which guide the successful engineer in his designing, so far as the constructive features are concerned. Mere statements and facts should be subjected to the idea of bringing out the reasons pro and con in any given case. Suitable exercises to be worked out in the drawing room should accompany this work. These may consist of combinations of several pieces shown in section and otherwise, so that the student learns the relation of the drawing to the *thing*, and in assembling these several pieces he learns the relation between the individual thing and the machine. For this work the exercises may be taken in part from sketches made by the student, and in part from the blue prints of details of machine parts which may be obtained from the manufacturer, or they may be taken from senior designs. This work should extend through to the end of sophomore year, or for a period of twenty-four weeks. One lecture, and from five to eight hours per week, inspecting, sketching, and drawing, may be very advantageously devoted to this subject. The student is thus prepared at the beginning of junior year to take up the study of machine design.

Machine design is both a science and an art. It is a science in that it is based upon rational deductions; it is an art in that it requires skill and judgment in applying these deductions to the engineering materials which are available. Calculation from a given formula is not machine design; judgment, or what has been termed "horse sense," enters quite prominently as a factor in the work. If calculation calls for a 60-inch boiler to be 2 inches thick, the designer must know intuitively that something is wrong. He should also be sufficiently informed on shop practice and methods that when he designs a piece of work he must know whether it can be made in the shop.

In the designing of new machines and mechanical constructions, the draftsman must draw from his knowledge of well-known forms and parts and combine them; but to proportion them properly and adapt them to the purposes required, he must take into consideration the stresses to which they are subjected, and the behavior of the available material under varying conditions. The choice of suitable dimensions and forms is the work of the machine designer.

Engineers and practical shop men are enabled to proportion the various machines which are daily manufactured, and to satisfactorily design new machines, without a knowledge of the character of the forces acting in the various parts of the machine; but it is safe to assume that this knowledge has been obtained only as a result of long experience and the process of substitution—that is, when a part failed in a machine a larger or stronger piece was substituted in the next one built—an expensive method of design.

The shop designer is frequently an averager, who obtains his results largely from the catalogues and publications of other manufacturers; and, while this is valuable as affording a means of comparison and corroboration, we believe that all intelligent mechanical design must be based on a knowledge of scientific principles. On the other hand, there is a difficulty in proportioning many machine parts on account of the lack of exact information, and of their variable functions not amenable to exact rules. For such cases empirical formulas and tables made up from the results of experiment and practice will be found of great assistance to the designer.

From these considerations it will be seen that the province of the instructor in machine design is to teach the principles available as guides in machine design, and to furnish such examples to be worked out at the drawing board as will ultimately tend to the development of the student's engineering knowledge. The teacher of machine design should evidently be a man familiar with practical shopwork and modern methods, but he should not attempt to cram the student full of facts and

tables. If the underlying principles are made prominent let the instructor feel that his work is well done; for development into the full-fledged engineer can not occur at once. It takes time, and we must remember that there is inertia in mind as well as in matter.

The teacher of machine design must also guard himself against giving the student formulas without showing their derivation and the relation of the several factors involved. It is not teaching principles if we select a dozen or more formulas with constants already determined and say to the student: Draw a piston rod end, for instance, making the diameter of rod equal to one sixth of the diameter of cylinder. If this is the way to teach our boys, why not get out tables for general cases and put them into the hands of our students? The average student is a reasonable and a reasoning person, but even a student is limited in capacity. For this reason we should so much the more teach principles as foundations and let the character of the individual problems be determined by the ability of the man. It is unwise to gauge all men by the same standard, and the old saying, "You can't make a whistle out of a pig's tail," should constantly be borne in mind by the college professor who puts all his men through the same work in machine design and expects all to be equally gifted in designing. If a boy has capacity for engineering he may be given problems and designs to work out that a man of less natural ability could not possibly execute. Although natural aptitude is a great advantage in this work, much can be acquired, and the teacher must judiciously direct the work of each student in order that he may thereby the better prepare the individual for his future vocation.

Before entering upon the real work of the drawing room it is advisable to spend about three weeks in the recitation room (three hours per week) in a general discussion of the engineering materials and the principles and general rules of calculation which are applicable to problems that may arise in the determination of machine parts.

The subject-matter taken up under these heads is not intended to displace nor should it be substituted for the study of metallurgy and applied mechanics. The properties and strength of engineering materials and the principles relating thereto are to be considered as an equipment of suitable tools which will enable a man to intelligently design those simple elements of which a machine is composed. The hasty preliminary view of the field is merely to indicate to the student where these tools may be found.

From six to ten hours per week for twenty-eight weeks should be devoted to the design of machine elements, such as those which come under the head of fastenings, gearing, pulleys, shafts, and bearings. This may be followed by problems in kinematics relating to straight line motions, quick return motions, and various cam motions, after which practice should be given in the application of Zeuner's diagram to valve gears. Eight to ten hours per week for twelve weeks are necessary for this portion of the work. At the beginning of senior year steam-engine design may be taken up and carried on for sixteen weeks, seven to nine hours a week being necessary for the work. Upon its completion the student takes up the design of machine tools, boilers, pumps, clutches, hoisting, punching, and other machinery. The time allotted to this section of the subject should vary from eight to twelve hours per week for twenty-four weeks. It will be found that quite a number of men will even spend as much as twenty hours per week on this work if permitted to do so.

The method of teaching machine design as carried on at Purdue University varies with the character of the work. So far as possible the students are given individual problems so that each may make his own calculations and become familiar with the method and application of the formula involved. Preceding each new series of problems a short lecture is given to the class, in which are pointed out the underlying principles relating to the problems, and the derivation and application of the formula to be used are explained, and reasons noted why other proportions should be

adopted under other conditions. In these problems each part is designed to do some definite work for which the data are given or may be determined.

Upon the completion of these elementary problems the student is given a course of exercises in kinematic and valve-gear problems, as previously indicated. With the commencement of senior year he takes up steam-engine design. In this work a given horse power of engine is assumed, suitable limits are chosen, and the indicator cards drawn for minimum, maximum, and normal conditions. These diagrams are modified to conform to practical conditions; and the diameter, length of stroke, and speed of the engine are determined after the tangential pressures upon the crank pin have been ascertained from assumed inertia effects. Instruction is given by means of lectures and drawing-room notes. Each student makes a complete set of theoretical diagrams in pencil on sheets 24 by 36 inches (standard size for senior drawings), after which the details of the engine are worked up by the class collectively—one man takes the cylinder, another the bed, another the crosshead and connecting rod, and so on. In designing these details the student has access to a good reference library in the drawing room and a very complete collection of trade catalogues and working blue prints from manufacturers, so that he has every means of becoming informed in regard to current practice.

In the design of details and in machine drawings which follow this work, the tracings are made direct from the penciled drawings. When completed, each student obtains a full set of blue prints. Conventional shop practice is used throughout all the work in machine design, and this is especially emphasized during the senior year where greater occasion for its use arises. For calculation and preliminary notes a system has been adopted by which the work and results are kept distinct, and yet both are preserved for future reference or comparison. The advantage of any such system in locating errors is apparent. In the present case notes, formulas, and results are kept on one page, while the calculations are made on the opposite page, so that the work and results are together, yet distinct. No attempt is made to economize paper, the only object aimed at being to save time, and this is best obtained by teaching the student to systematize his work and have the calculations where they may be referred to in case of error or in checking results. During the progress of the work, especially in scale drawings, the draftsman is encouraged to make full-sized sketches of the several parts of his design in order that he may obtain a better degree of proportion. To this end, specially prepared section paper is provided, so that the part may be rapidly sketched in freehand without other reference to size than that furnished by the paper itself.

The concluding work of the senior year consists of special designs, assigned individually, according to ability and circumstances. This work is generally presented in the form of a problem which involves more or less engineering knowledge and the exercise of judgment in the application of principles studied earlier in the course. Time blanks are used for these designs, as it is thought that a record of the work and time spent on it is advantageous to both student and instructor. Instruction is given in this work by means of consultation with the student, advice, and corrections. References are cited when the problem is assigned. As the design progresses many of the details are sketched off and worked up by under-classmen. For this purpose several of the more advanced freshmen and sophomores are detailed as assistants to the seniors, and from an experience of two years the plan can be indorsed as producing excellent results. The senior is given a responsibility which insures greater care and thoroughness on his part, besides which it enables him to accomplish a great deal more of real shopwork than would otherwise be the case. There is also an advantage to the under-classman, as he is brought more intimately in contact with a class of work as nearly as possible similar to that carried on in engineering drawing rooms.

Recapitulating and taking the average time allowance, it will be seen that we advocate a course in mechanical drawing covering four years and occupying a total of 1,168 hours, allotted as follows:

Hours occupied in mechanical drawing.

Class.	How occupied.	Hours per week.	Number of weeks.	Total hours.
Freshman year	Freehand drawing and lettering.....	6	16	96
	Instrumental drawing: Tracing, blue printing, shading, tinting, isometric.	8	24	192
Sophomore year	Descriptive geometry, shades, and shadows	6	16	96
	Mechanism sketches, assembling, and section drawing.	6	24	144
Junior year	Design of machine elements, cam motions, and valve gears.	8	40	320
Senior year	Steam-engine and machinery design.....	8	40	320
	Total			1,168

APPENDIX.

MINUTES OF SECTIONS.

SECTION ON AGRICULTURE AND CHEMISTRY.

The Section on Agriculture and Chemistry held but a single meeting, in which the only work done was to elect officers for the coming year.

SECTION ON COLLEGE WORK.

Much of the work usually coming before this Section during the annual conventions of the Association was merged with that of the various agricultural congresses in session at the same time and place. Two sessions only of the Section were held.

The first session was called to order at 11 a. m., October 17, President Dabney in the chair. The secretary of the Section, President Fernald, of Maine, being absent, President Stockbridge, of North Dakota, was elected to serve in his place. The report of the president of the Section, Dr. Dabney, read in the general session of the Association, was brought up for consideration. On motion of President Scott, of New Jersey, it was voted that the report of the president be referred to a committee of three, with instructions to embody the recommendation of the report and those of the Inspector General of the Army on the same subject, namely, military instruction in land-grant colleges, in a resolution to be presented to the War Department as the sense of the Section. Messrs. Scott, Welborn, and Harris were named as such committee. The Section then adjourned.

The second meeting of the Section was called to order at 12 m., October 18, President Dabney in the chair. No business was brought up except the election of officers for the ensuing year, resulting as follows: President, President Fairchild, of Kansas; vice-president, President Harris, of Maine; secretary, President Stockbridge, of North Dakota. The Section then adjourned *sine die*.

H. E. STOCKBRIDGE,
Secretary.

SECTION ON HORTICULTURE AND BOTANY.

The following papers were presented by Prof. B. D. Halsted, of New Jersey:

THE SOLANDI PRINTING.

By B. D. HALSTED, of *New Jersey*.

Your worthy secretary suggests that the papers before the Section be mainly upon methods and plans; therefore the following process of making records of various results is given. It was given at the Madison meeting of the American Association for the Advancement of Science, but as many of the station botanists and horticulturists were absent, and because several have expressed an interest in the process, it is again stated in brief: It is a process of sun printing, and can be employed for any subject not too thick or dark to admit the passage of light. With leaves and objects similar to them it is particularly well adapted. The process consists in exposing an object like a leaf, for example, to the sunlight while closely held upon sensitized paper, the aristotype paper being the kind most experimented with in an ordinary photographer's printing frame.

This sun print thus obtained is toned in the same way as an ordinary photograph print. This print becomes a negative, from which a positive is printed. To do this the negative is placed in kerosene for a minute, wiped clean, and put in a printing frame, faced by aristo paper. This positive is toned in the same way as was the negative, and the work of taking a picture is finished, and, if well done, there is an exact reproduction of very many of the details of the subject.

If green leaves or subjects be taken fresh, they need no previous treatment, the only precaution being to have them dry upon the surface exposed to the aristo paper. When dry subjects are used, they may be placed in the kerosene for a short time, which only makes them more translucent in the lighter parts and facilitates the printing.

There are many subjects that yield better results by the Solandi process than by photography. The former is by transmitted light, and brings out some of the peculiarities that lie beneath the surface and are not, therefore, secured by photography.

The cheapness and ease of the process commend it to everyone who desires exact prints of various objects. There is no camera needed, no sensitized glass plates, or even a dark room. A photographer's printing frame and a few cents' worth of aristo paper are sufficient to secure a dozen pictures. The toning is easily done, costs but a little for a hundred pictures, each one of which is absolutely natural size and the details represented without distortion.

Samples of the work are shown, and they must speak for the process.

FIELD OBSERVATIONS WITH FUNGI.

By B. D. HALSTED, of *New Jersey*.

The study of destructive fungi has been confined very largely to the laboratory. This has been as it should be, for it is only with the compound microscope and various methods of tube and plate cultures that the nature of the pest may be determined. It seems to me that this indoor work with many of the parasitic fungi

has gone far enough to be at least supplemented by observations in the field. While it is well to study the fungi minutely and separately, often the best results, particularly from a practical standpoint, are to be derived from careful and continuous field observations.

The following instance may help to enforce the above, and, while it is drawn from my own notebooks, it serves the purpose of calling the minds of other students of similar subjects to the importance of making similar observations:

In 1892 a laboratory study was made of the quince diseases, and particularly one known as the black rot, then very destructive. The microscopic study developed strong suspicions that the fungus was the same as that causing a similar decay of apples, namely: *Sphaeropsis malorum* Peck. Inoculations were easily made from the quince to the apple and *vice versa*. Having established the identity of the black rot of the quince and apple by laboratory methods, attention was turned to the orchard, when it was soon found that one apple tree standing near the center of the grove of quince trees and loaded with fruit abounded with the *Sphaeropsis* while the quinces nearest to this tree were the most affected. It was then found that the same relations existed between a similar rot of pears and the above-mentioned apple tree, and this decay was shown by inspection and cultures in the laboratory to be due to the same fungus. These are instances of important information, aided by field observations, and are introductory to a study that was made in the same field early in the present season.

Feeling assured from other experiments of the value of beginning in time the apple tree was visited in June, and this proved none too soon. One large branch loaded down with fruit was a graft of the Red Astrachan, and at that time many of the fruits were decaying upon this branch, while those upon the other portions of the tree were yet small, green, and sound. This fact of observation taken with those of last season, in this single branch of the Red Astrachan, was the beginning of the serious trouble from black rot in the orchard and particularly with the quinces. In other words, while in 1892 the field observations traced the possible source of the rot to a single apple tree, those of the present season pointed out that the *Sphaeropsis* started and gained headway in the early maturing fruit of a single large branch of that tree.

From the remedial standpoint the suggestion comes naturally that either the whole apple tree should be removed—that was the advice given last year—or the branch of the early sort cut away. This latter may prove to be the desired check and should be tried. This is a case of saving the life at the expense of the limb and comes under one of the rules of modern advanced surgery.

If our knowledge of the field habits of fungi were better known examples similar to the one cited might be given without number.

At the present time the writer is attempting to gather information upon the relationship which one cruciferous crop bears to another in the matter of clubbing of the roots, due to the low fungus *Plasmodiophora brassicae* Wor. It seems to prefer the roots of the cabbage, but within the past month most aggravated cases of it have been found upon turnips. Radishes are least affected, and the point of observation is to see how much risk is run by growing turnips after cabbage and radishes after either, also how long the fungus may remain virulent in the soil. Not the least item in the examination of the roots of wild weedy *Cruciferae*, as suspicion rests upon them as the "common carriers" of this underground enemy.

A final suggestion in the matter of an appeal for more field study of fungi is that of coöperation. The time element is the only one that stands in the way of botanists from Maine to California working together upon some problems requiring only the use of the eyes while in the field, orchard, and garden, and recording the facts so obtained. In laboratory studies we can not expect to coöperate largely, but in field observations there is no barrier against it. Therefore let us do more field work with fungi at odd hours, mingled with recreation at times it may be, and labor helpfully together upon some of the numerous subjects that can not fail to interest many if not all the station botanists and horticulturists.

SECTION ON MECHANIC ARTS.

According to the plans of the Association, the Section on Mechanic Arts of the Association of American Agricultural Colleges and Experiment Stations held its first annual meeting in Hall IV of Art Palace, on Michigan avenue, Chicago, on Wednesday evening, October 18, 1893.

The meeting was called to order at 7:15 p. m. by Chairman C. W. Hall, of Minnesota. This meeting being the first held by the new Section, no minutes were read.

Prof. C. W. Hall, of Minnesota, presented a paper on "Some Relations of Mechanic Arts to Agriculture." The production showed concisely how intimate the agricultural and mechanic arts were and how they could assist each other in individual development. The paper created considerable discussion and a free exchange of opinions regarding manual training operated in connection with agricultural colleges.

In the absence of Prof. G. W. Bissell, of Iowa, his paper on "Shop-work at the Iowa Agricultural College" was read by the secretary of the Section.

Prof. Bissell outlined the system of shop instruction at the Iowa Agricultural College, and illustrated his methods by a very complete set of blue prints.

Although the article was specific, the presentation of the exercises used in one college was fruitful of interesting discussion.

On motion of Maj. H. E. Alvord, the papers read were ordered incorporated in the general proceedings of the Association.

On motion of F. P. Anderson, the three remaining papers on the program were read by title and referred to the executive committee of the Association for publication.

The other papers prepared for the Section on Mechanic Arts, and which were referred for publication, are:

"Mechanical Drawing in Technical Schools," by Prof. J. J. Flather, of Purdue University.

"Manual Training and the Apprentice System," by Prof. C. Russ Richards, of University of Nebraska.

"What Tools are Necessary in a Manual Training Course," by Prof. H. E. Smith, of University of Minnesota.

In the general discussion following the reading of the papers some interesting questions were examined relative to the amount and char-

acter of shopwork that should be given to agricultural students. Expressions of opinions came from Maj. H. E. Alvord, Prof. W. C. Latta, of Indiana; Prof. Lewis McLouth, of South Dakota; Prof. J. H. Washburn, of Rhode Island; Prof. C. W. Hall, of Minnesota; President A. W. Harris, of Maine; and Prof. Hugh Jamieson, of Louisiana.

The qualifications of instructors in shopwork were freely discussed, the universal opinion being that a man having a practical shop experience, together with that training received in a technical school, is the most desirable instructor in manual training.

No further business was transacted, and the first meeting of the Section on Mechanic Arts, considering the diverting influences of the Columbian Exposition, proved very successful.

F. P. ANDERSON,
Secretary.

INDEX.

NAME LIST.

- | | |
|--|---|
| Alvord, H. E., 11, 15, 16, 19, 22, 31, 33, 34, 36, 51, 58, 60, 64, 95, 96. | Hays, W. M., 14, 59. |
| Anderson, F. P., 11, 13, 61, 95, 96. | Hebard, G. R., 15. |
| Anderson, J. W., 74, 75, 76, 77. | Henry, W. A., 11, 15, 19, 30, 37, 38, 45 |
| Armsby, H. P., 14, 34, 37, 52. | Hickman, J. F., 14. |
| Atherton, G. W., 14, 52, 58, 59, 64. | Hills, J. L., 15. |
| Atwater, W. O., 48. | Hinds, H. H., 52. |
| Babcock, S. M., 37, 52. | Hinebauch, T. D., 14. |
| Backhaus, A., 38. | Holcombe, J. W., 15, 35. |
| Balentine, W., 13. | Hunnicutt, J. B., 13. |
| Battle, H. B., 14. | Hunt, T. F., 14. |
| Bennett, R. L., 13. | Huston, H. A., 13. |
| Bissell, G. W., 65, 95. | Jamieson, jr., H., 13, 96. |
| Black, S. E., 15. | Jones, J. M., 13. |
| Bondurant, A. J., 13, 60, 65. | Johnson, A. A., 31. |
| Bowker, W. H., 14. | Johnson, S. W., 11, 31, 64. |
| Brigham, J. H., 14. | Kellogg, A. L., 13, 37, 60. |
| Bruner, L., 29. | Koons, B. F., 13, 59. |
| Buchanan, W. I., 21, 34, 38, 52, 56. | Latta, W. C., 96. |
| Buffum, B. C., 15. | Lawes, J., 46, 47, 48. |
| Caldwell, W. H., 14, 52. | Lazenby, W. R., 14, 61. |
| Canfield, J. H., 11, 64. | Lee, S. D., 11. |
| Cavitt, W. R., 14, 59, 60, 64. | Magruder, A. C., 14. |
| Comstock, J. H., 14, 61. | Mayo, N. S., 13. |
| Craighead, E. B., 14. | McGee, W. L., 14. |
| Curtiss, C. F., 13. | McKinney, R. C., 76. |
| Dabney, jr., C. W., 14, 37, 58, 59, 92. | McLouth, L., 14, 96. |
| Detmers, H. J., 14. | Menami, T., 38. |
| DeVuyst, P., 38. | Miller, R. H., 13. |
| Ellis, S. H., 14. | Morrow, G. E., 11, 13, 21, 37, 38, 64. |
| Emery, S. M., 14, 24. | Murkland, C. S., 14. |
| Fairchild, G. T., 11, 13, 29, 37, 51, 60, 92. | Myers, J. A., 15, 58, 59, 61. |
| Farrington, E. H., 13, 37, 55, 56. | Newman, J. S., 11, 64. |
| Fay, J. A., 75, 76, 78. | Osborn, H., 11, 61. |
| Fernald, M. C., 92. | Pammel, L. H., 11, 13, 61. |
| Flagg, C. O., 14. | Patterson, J. K., 13, 68. |
| Flather, J. J., 81, 95. | Patterson, W. A., 13. |
| Frear, W., 11, 14, 60, 64. | Plumb, C. S., 13. |
| Fuller, V. E., 52. | Porter, E. D., 14. |
| Gilbert, H., 17, 37, 45, 46, 51. | Powers, H., 21. |
| Gillette, C. P., 13. | Pratt, F. A., 74. |
| Glidden, A. C., 14. | Redding, R. J., 31. |
| Goessmann, C. A., 14. | Reynolds, M. H., 14. |
| Goff, E. S., 11, 61. | Richards, C. R., 73, 95. |
| Goodell, H. H., 11, 64. | Roberts, I. P., 14, 37, 43, 52, 61. |
| Gulley, F. A., 13, 59. | Robinson, J. A., 15. |
| Hadley, H., 11, 14, 22, 64. | Rose, A. J., 14, 64. |
| Hall, C. W., 61, 67, 95, 96. | Scott, A., 14, 22, 59, 92. |
| Halsted, B. D., 92. | Scovell, M. A., 11, 13, 16, 22, 37, 52, 58, 64. |
| Harris, A. W., 11, 13, 21, 24, 30, 31, 34, 60, 61, 64, 92, 96. | Sellers, W., 77. |
| | Silvester, R. W., 13. |

Slieskin, P., 38.
 Smith, C. D., 14.
 Smith, H. E., 95.
 Smith, H. W., 15.
 Springer, J. H., 76.
 Starnes, H. N., 13.
 Steele, C. L., 14.
 Stockbridge, H. E., 11, 14, 60, 92.
 Street, W. D., 13.
 Sturgis, W. C., 13.
 Taft, L. R., 61.
 Taliaferro, W. T. L., 13.
 Thorne, C. E., 14, 59, 61, 64.
 Townshend, N. S., 14.
 True, A. C., 15, 31, 35, 36, 37.
 Vanderford, C. F., 14, 24.

Vassilliere, P., 38.
 Veeder, J. D. W., 14.
 Voorhees, E. B., 11.
 Warder, R. H., 14.
 Warington, R., 47.
 Washburn, J. H., 11, 14, 59, 61, 96.
 Weber, H. A., 14.
 Weed, C. M., 11, 61.
 Welborn, W. C., 14, 37, 92.
 Wheeler, J., 13.
 White, H. C., 11, 64.
 Willits, E., 34.
 Wilson, J., 13.
 Withers, J. S., 14.
 Woll, F. W., 15.
 Zavitz, C. A., 15.

SUBJECT LIST.

	Page.
Agricultural education in France.....	38
Germany	38
Japan.....	38
Russia.....	38
intellectual development.....	51
experiment stations, list of directors.....	3
relation of General Government.....	38
societies and other agricultural forces in Belgium.....	38
investigation at Rothamsted, England.	46
Agriculture and chemistry, officers of section	60
minutes of section.....	91
Annual address of president.....	38
conventions, how to increase attendance of station officers.....	61
meeting of convention, resolution	64
Apprentice system and manual training.....	73
Association, constitution	7
officers	11
proceedings	19
programs.....	17
report of executive committee.....	19
resolution concerning name	64
Botany and horticulture, officers of section	61
Bureau of Education, address of chief clerk.....	35
Bust of Hon. Justin S. Morrill, resolution concerning.....	60
Call for convention	16
College work, minutes of section	92
officers of section	60
report of section.....	25
Constitution of association.....	7
Convention, call.....	13
Dairy test, cost.....	57
report of committee	52
resolution of thanks to committee.....	58
Delegates, list	13
Director of Office of Experiment Stations, address on work	31
Directors of agricultural experiment stations, list	3
Dues of institutions, resolution concerning.....	60
Education, agricultural, in France.....	38
Germany	38
Japan.....	38
Russia.....	38
intellectual development.....	51
Education, Bureau of, address of chief clerk.....	35
technical	67
Entomology, officers of section	61
Executive committee, report	19
Expenditures of stations, resolution concerning inspection by Government.....	64
Field observations with fungi.....	93
Fungi, field observations	93
Horticulture and botany, minutes of section.....	93
Intellectual development in agricultural education.....	51
Inspector General of Army, resolutions approving recommendation	59
Iowa State College of Agriculture and Mechanic Arts, shopwork instruction.....	65
Lawes Agricultural Trust, resolutions concerning	59
List of delegates and visitors	13
Rothamsted field experiments	49

	Page.
Manual training and the apprentice system	73
Mechanical drawing in technical schools	81
Mechanic arts, minutes of section	95
officers of section	61
Minutes of sections	89
section on agriculture and chemistry	91
college work	92
mechanic arts	95
horticulture and botany	93
Morrill, Hon. Justin S., resolution concerning bust	60
Nominating officers, committee	59
Nominations, report of committee	64
Office of experiment stations, address of director on work	31
card index	31
resolution requesting report of exhibit	58
Officers, committee for nominating	59
of association	11
experiment stations, concerning reports to Department of Interior	35
section on agriculture and chemistry	60
botany and horticulture	61
college work	60
entomology	61
mechanic arts	61
Plants and seeds, resolution concerning distribution by the Government	37
President, annual address	38
Printing, solandi	93
Proceedings of association	19
resolution concerning publication	60
Program, general sessions	17
Relations of General Government to agricultural experiment stations	38
Report of committee on dairy tests	52
on nominations	64
executive committee	19
exhibit of Office of Experiment Stations, resolution requesting	58
section on college work	25
treasurer	22
on collective exhibit of World's Columbian Exposition	34
uniformity of station publications	30
Resolution concerning annual meeting	64
bust of Hon. Justin S. Morrill	60
continuation of committees	58
distribution of plants and seeds by the Government	37
dues of institutions	60
inspection by Government of expenditures of stations	64
Lawes Agricultural Trust	59
name of association	64
publication of proceedings	60
unfinished business	60
of thanks to committee on dairy tests	58
requesting report of exhibit of Office of Experiment Stations	58
Resolutions approving recommendation of Inspector General of Army	59
concerning exhibit of France at World's Columbian Exposition	59
Rothamsted field experiments, list	49
Seeds and plants, resolution concerning distribution by the Government	37
Shopwork instruction at the Iowa State College of Agriculture and Mechanic Arts	65
Solandi printing	93
Station exhibit, collective, of World's Columbian Exposition, report of committee	34
officers at annual conventions, how to increase attendance	61
publications, report on uniformity	30
Technical education	67
schools, mechanical drawings	81
Treasurer, report	22
Unfinished business, resolution concerning	60
Uniformity of station publications, report	30
World's Columbian Exposition, report on collective station exhibit	34

U. S. DEPARTMENT OF AGRICULTURE.
OFFICE OF EXPERIMENT STATIONS.

METHODS AND RESULTS
OF
INVESTIGATIONS
ON THE
CHEMISTRY AND ECONOMY OF FOOD.

BY

W. O. ATWATER, Ph. D.,

*Professor of Chemistry in Wesleyan University,
Director of the Storrs (Conn.) Agricultural Experiment Station, and
Special Agent of the United States Department of Agriculture.*

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1895.

CONTENTS.

	Page.
CHAPTER I. INTRODUCTION	9
Public need of information about food economy	9
Purpose and plan of this bulletin	10
Collaborators	10
CHAPTER II. FOOD AND ITS USES FOR NUTRIMENT	11
Composition of food materials—Nutrients and their func- tions in nutrition	11
Classes of nutrients	11
Uses of food—Functions of nutrients	12
Building and repair—Functions of protein compounds	13
Fuel—Functions of fats and carbohydrates	13
The potential energy of food—Fuel value	14
Definition of food	16
CHAPTER III. COMPOSITION OF FOOD MATERIALS	17
Historical development of food analysis	17
Analyses of American food products	19
Tables of composition of American food materials	21
Analyses of sides of beef and mutton	21
Composition of side of beef	23
Composition of side of mutton and side of lamb	24
Work now needed in analysis of foods	38
Improvement of methods of analysis	38
CHAPTER IV. THE DIGESTIBILITY OF FOOD	53
The quantities of digestible nutrients in food	54
Historical summary	56
Experimental methods	56
Method of quantitative test of proportions of nutrients digested from food by man	57
Results of experiments upon quantities of nutrients di- gested from different foods	60
Further considerations regarding digestibility	71
Effects of preparation of food upon digestibility—Cooking	73
Effects of food adjuncts on digestion—Flavoring materials	76
Summary	78
Suggestions as to experimental work now needed	79
CHAPTER V. PREPARATION OF FOOD—COOKING	81
Preparation of food—König's summary of investigations	81
Effects of condiments upon digestion	81
Effects of cooking upon digestibility and nutritive value	83
Boiling, broiling, and roasting of meats and other ani- mal foods	83
Baking of bread	91
Effects of cooking as stated by Halliburton	91
Atkinson's definition of cooking	92
Investigations by Mrs. Richards and Mrs. Abel	92
Essentials for good cooking apparatus	93
Cookery of meat	94
Composition of beef juice, beef tea, etc	96
How long broth may be kept	96
Pea soup	97
Suggestions as to investigations needed	97
Effects of cooking on digestion	98

	Page.
CHAPTER VI. USES OF FOOD IN THE BODY—METABOLISM	99
Metabolism of matter and energy in the body	99
Metabolism of material—Daily income and expenditure of the body	101
The respiration apparatus.....	106
CHAPTER VII. METABOLISM OF ENERGY—INCOME AND OUTGO OF BODY	113
Potential energy of food—Heats of combustion—Fuel values	115
Calorimeters and calorimetry—Historical development....	116
Thompson's calorimeter—Investigations of Frankland.	116
Stohmann's calorimeter and investigations	119
The bomb calorimeter of Berthelot.....	120
Modifications of the bomb calorimeter by Mahler, Hempel, and Atwater	123
Results of determinations of heats of combustion	126
Investigations of heats of combustion now needed	129
Isodynamic values of nutrients	130
Fuel values of protein, fats, and carbohydrates.....	133
Respiration calorimeters	133
Rubner's experiments with the respiration calorimeter ...	134
Other respiration calorimeters.....	135
CHAPTER VIII. PECUNIARY ECONOMY OF FOOD.....	136
Cheap <i>v.</i> dear food	137
CHAPTER IX. FOOD CONSUMPTION.....	141
Studies of dietaries—Historical summary.....	141
Special investigations of dietaries.....	143
Dietary studies in the United States	144
Investigation of dietaries in connection with the Massa- chusetts Bureau of Statistics of Labor.....	144
The dietaries and the people nourished by them.....	145
Dietary of a boarding house in Connecticut	155
Dietaries of hand weavers in Zittau, Saxony.....	163
Dietaries of people of the poorer classes in Naples	173
Tabular statements of results of dietary studies.....	177
Comments upon dietaries summarized in Table 37.....	184
Suggestions regarding studies of dietaries	198
Classes of people and localities for dietary studies	205
CHAPTER X. STANDARDS FOR DIETARIES.....	206
Methods of estimating dietary standards.....	206
European and American dietaries and standards.....	207
Suggestions for dietary standards	212
CHAPTER XI. ERRORS IN OUR FOOD ECONOMY	214
Cheap <i>v.</i> dear food.....	215
Food of the poor	215
One-sidedness of our dietaries.....	216
Overeating—Injury to health	217
Waste of food in American households	219

LIST OF ILLUSTRATIONS.

	Page
Fig. 1. Diagram of cuts of beef.....	23
Fig. 2. Cells of a raw potato, with starch grains in natural condition	88
Fig. 3. Cells of a potato boiled in water one-half hour	89
Fig. 4. Cells of a potato well steamed and mashed	89
Fig. 5. Pettenkofer's respiration apparatus	106
Fig. 6. Pettenkofer's respiration apparatus. Pumping machinery	107
Fig. 7. Pettenkofer's respiration apparatus. Explanatory sketch	108
Fig. 8. Voit's respiration apparatus	108
Fig. 9. Thompson's calorimeter.....	116
Fig. 10. Stohmann's calorimeter.....	119
Fig. 11. Berthelot's bomb calorimeter	121
Fig. 12. Mahler's bomb calorimeter as mounted for use.....	122
Fig. 13. Bomb calorimeter as modified by Hempel and Atwater	124
Fig. 14. Bomb calorimeter of fig. 13, as mounted and standing in water	125
Fig. 15. Top of bomb calorimeter of fig. 13	126
Chart 1. Composition of food materials	22
Chart 2. Pecuniary economy of food.....	138
Chart 3. Dietaries and dietary standards	208

LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., October 20, 1894.

SIR: I have the honor to transmit herewith for publication Bulletin No. 21 of this Office, on "Methods and Results of Investigations on the Chemistry and Economy of Food," by W. O. Atwater, Ph. D. The circumstances which have led to the publication of the present bulletin need, perhaps, some words of explanation. Investigations of the hygienic and pecuniary economy of food are of comparatively recent date. It is scarcely fifty years since the classical researches of Liebig began to pave the way for finding practically all we know to-day of the ingredients of our food materials, the ways in which they are used in the body, and the kinds and combinations which are best adapted to health and purse. Nearly all of the best experimental inquiry in these lines has been carried on in Europe. There have, indeed, been pioneers in the United States, but their work belongs mostly to the last two, and all of it to the last three, decades. The first analyses by modern methods of materials used for the food of man or domestic animals in this country were made in 1869 by the author of this bulletin, then a student in the Sheffield Scientific School of Yale University. With the rise of the experiment stations, inquiries into the composition of feeding stuffs and their appropriate use in the nutrition of domestic animals have been undertaken and during the past few years have been carried on quite actively. The first at all extensive series of investigations of materials used as the food of man undertaken in the United States were studies of the chemistry of fish, prosecuted under the auspices of the United States Fish Commission in the chemical laboratory of Wesleyan University by Professor Atwater in the years 1878-1881. In connection with this work, analyses of meats and other food materials were made under the auspices of the Smithsonian Institution.

The first accurate investigation of the chemical and economical statistics of food consumption in the United States were undertaken in the year 1886 by Col. Carroll D. Wright, then chief of the Massachusetts Bureau of Statistics of Labor and now United States Commissioner of Labor, in cooperation with Professor Atwater at Middletown, Conn. Thus far but extremely little has been done in the United States by way of exact experimental inquiry regarding the laws of human nutrition. But the growth of the preliminary forms of investigation points to a speedy development of research of a high character

in this direction also. It is a very gratifying fact that already a considerable amount of investigation regarding the composition of our food materials and the economy of their use has accumulated, and, what is more to the point, earnest and capable investigators are addressing themselves to the still more extended and thorough study of the subject.

A large part of the work thus far done in the United States has been at private expense. But, as often happens, the inquiries thus benevolently begun have proven so useful that public funds are becoming available for their prosecution. On the recommendation of the Secretary of Agriculture the sum of \$10,000 was included in the appropriations for the Department of Agriculture for the present fiscal year, the purpose of which is to enable him to investigate and report upon the food economy of the people of the United States. The supervision of the investigations thus provided for has been assigned to the Office of Experiment Stations, and Professor Atwater has been appointed special agent in charge.

The agricultural experiment stations established by authority of Congress are authorized to make inquiries in this same direction, and are called upon to report their results to the Secretary of Agriculture. In order to facilitate such investigations, not only by investigators in experiment stations, but by those associated with the colleges and other institutions for research and instruction, it has seemed desirable to prepare a statement of the results of inquiries already reached, questions which now demand attention, and the best methods for their study. It was, however, found impracticable to make a complete presentation of the subject without greatly delaying the publication of such information as seemed almost essential to the further prosecution of researches in this line in this country. An effort has therefore been made to outline in a general way the field to be traversed, to show with detail sufficient for present purposes what portions need first to be cultivated and to indicate how the work should be carried on. It is hoped that the remaining material may in due time be collated and published.

Respectfully,

A. C. TRUE, *Director.*

Hon. CHAS. W. DABNEY, Jr.,
Acting Secretary of Agriculture.

THE CHEMISTRY AND ECONOMY OF FOOD.

CHAPTER I.

INTRODUCTION.

PUBLIC NEED OF INFORMATION ABOUT FOOD ECONOMY.

Food constitutes the chief item of the living expenses of the people, of our agricultural production, and of our exports. Half the earnings of wage workers in this country and in Europe is spent for food. The health and strength of all are intimately dependent upon their diet. Yet most people understand very little about what their food contains, how it nourishes them, whether they are economical or wasteful in buying and preparing it for use, and whether or not the food they eat is rightly fitted to the demands of their bodies. The result of this ignorance is great waste in the purchase and use of food, loss of money, and injury to health.

Underneath all this is still another evil. Our food products as a whole are not such as are best fitted for healthful and economic nutrition or for the most profitable export. Our agricultural production is out of balance. Here, again, the facts are not clearly understood, as they must be to make the needed reform possible.

The reason for this ignorance is simple enough. Fifty years ago no man knew what our bodies and our foods were composed of; how the different nutritive ingredients of the food served their purposes in nutrition; how much of each of the ingredients was needed to supply the demands of people of different age, sex, and occupation; and how best to adjust the diet to the wants of the user. We do not to-day know as much about these things as we ought. For that matter, we never shall be able to lay down hard and fast rules to apply to all cases, because of the differences between individuals in respect to their demands for nutriment and the ways in which their bodies can make use of different kinds of foods. But the research of the past twenty-five years has brought a great deal of definite information. Nearly all of the exact inquiry in this direction has been done in Europe, and the greater part of it in Germany. We are beginning it in the United States.

To remove this ignorance two things are needed. The first is a more definite knowledge of the actual facts. The second is that the information be brought to the people. The knowledge can be gained by research. To secure its diffusion the results of inquiry must be published in detail. They can then be popularized and made useful to the people at large.

PURPOSE AND PLAN OF THIS BULLETIN.

This bulletin has a twofold purpose: to summarize some of the results of late inquiry as to the physiological and pecuniary economy of food, and to indicate questions now demanding study and desirable methods of investigation.

Among the results of inquiry dwelt upon are the chemical composition of materials used for the food of man; the proportions of nutritive ingredients; their digestibility; their fuel values; the ratios between their values for nutriment and their cost; the kinds of food and proportions of nutrients best adapted to the demands of people of different classes and occupations; the errors in our food economy; and the sociological and agricultural bearings of the subject.

The questions proposed for study are such as the above-named topics suggest. They center around the general problem of food economy. Some are abstrusely scientific and reach into the higher realms of chemistry and physiology, but these are as necessary for the practical inquiry as the foundation is for the house. All bear directly or indirectly upon health, home life, and household, agricultural, and national economy. The methods of inquiry recommended are mainly such as have been elaborated more or less completely by experience and described succinctly by specialists. Some, however, are new and still in the process of development.

COLLABORATORS.

In the preparation of this bulletin the author has enjoyed the valuable assistance of Messrs. C. D. Woods, H. B. Gibson, and C. F. Langworthy. Mr. Woods has performed a large part of the labor of compiling the analyses of foods, and the results of his experience in the study of methods and the actual work of analysis in the laboratory during the last fifteen years or more are embodied in the description of methods of analysis recommended. He has also assisted in the studies of dietaries and compilation of results. Dr. Gibson, who has likewise shared in the studies of foods and dietaries for several years, has done a large part of the work of compiling the results of such studies. Dr. Langworthy has shared in the collating of studies of dietaries and has been especially helpful in the collating of the results of investigations of the digestibility of foods.

CHAPTER II.

FOOD AND ITS USES FOR NUTRIMENT.

A pound of lean beef and a quart of whole milk contain about the same amounts of actually nutritive material. But the pound of beef costs more than the quart of milk, and its nutrients differ not only in number and kind, but are, for ordinary use, more valuable than those of the milk. This illustrates a fundamental fact in the economy of foods, namely, that the differences in the values of different foods depend upon both the kinds and the amounts of the nutritive materials which they contain. Add to this that it is essential for health that the food shall supply the nutrients in the kinds and the proportions required by the body, and that it is likewise important, from a pecuniary standpoint, that the materials be obtained at the minimum cost, and we have the fundamental principles of food economy.

COMPOSITION OF FOOD MATERIALS—NUTRIENTS AND THEIR FUNCTIONS IN NUTRITION.

Ordinary food materials—such as meat, fish, eggs, potatoes, wheat, etc.—may be regarded as consisting of refuse and edible portion.

Refuse.—This includes the bones of meat and fish, shells of shellfish, skin of potatoes, bran of wheat, etc.

Edible portion.—This includes the flesh of meat and fish, the white and yolk of eggs, wheat flour, etc. The edible portion consists of *water* and nutritive ingredients, or *nutrients*.

Current usage recognizes the following as the principal kinds of nutrients: Protein, fats, carbohydrates, and mineral matters.

The water, refuse, and salt of salted meat and fish are here designated as “non-nutrients.” The water is, of course, indispensable for nourishment, but is not a nutrient in the sense in which the word is here used. In comparing the values of different food materials for nourishment the refuse and water are left out of account.

CLASSES OF NUTRIENTS.

The following familiar examples of compounds commonly grouped with each of the four principal classes of nutrients will serve to define the terms as here used, and may perhaps help to avoid the confusion

which unfortunately results from the variations in usage by different writers:

<i>Protein</i>	{	Proteids..	{ Albuminoids: e. g., albumen of eggs; myosin, the basis of muscle (lean meat); the albuminoids which make up the gluten of wheat, etc.	
			{ Gelatinoids: Constituents of connective tissue which yield gelatin and allied substances, e. g., collagen of tendon; ossein of bone.	
		{	“Nitrogenous extractives” of flesh, i. e., of meats and fish. These include kreatin and allied compounds, and are the chief ingredients of beef tea and most meat extracts.	
			Amids: This term is frequently applied to the nitrogenous non-albuminoid compounds of vegetable foods and feeding stuffs, among which are amido acids, such as aspartic acid and asparagin. Some of them are more or less allied in chemical constitution to the nitrogenous extractives of flesh.	
<i>Fats</i>	{	Fat of meat; fat of milk; oil of corn, wheat, etc. The ingredients of the “ether extract” of animal and vegetable foods and feeding stuffs, which it is customary to group together roughly as fats, include, with the true fats, various other substances, as lecithins and chlorophylls.		
<i>Carbohydrates</i>		Sugars, starches, celluloses, gums, woody fiber, etc.		
<i>Mineral matters</i> ...	{	Potassium, sodium, calcium and magnesium chlorids, sulphates and phosphates.		

An illustration of the prevalent confusion in the use of terms is found in those for the nitrogenous compounds. The words "albuminoids" and "proteids" are employed by different authors with very different significations. Some, for instance, apply the former of these terms to what are here called "gelatinoids." Others make a somewhat similar use of the term "proteids." Still others use one or the other of these terms for the whole nitrogenous material, which is here designated as "protein."

USES OF FOOD—FUNCTIONS OF NUTRIENTS.

The two chief uses of food of animals are: First, to form the materials of the body and repair its wastes; and, second, to yield energy in the forms of (1) heat to keep the body warm and (2) muscular and other power for the work it has to do. In forming the tissues and fluids of the body the food serves for building and repair. In yielding energy it serves as fuel for yielding heat and power.

The different nutrients of food act in different ways in fulfilling these purposes. The principal tissue formers are the albuminoids. These form the framework of the body. They build and repair the nitrogenous materials, as those of muscle, tendon, and bone, and supply the albuminoids of blood, milk, and other fluids. The chief fuel ingredients of the food are the carbohydrates and fats. These are either consumed in the body or are stored as fat to be used as occasion demands.

BUILDING AND REPAIR—FUNCTIONS OF THE PROTEIN COMPOUNDS.

The albuminoids are the building material of the body. The bodily machine is made from them, but in the making of the machine the albuminoids remain partly albuminoids and are partly changed to gelatinoids, so that the machine, as built, consists of both albuminoids and gelatinoids. The gelatinoids can not, according to the best evidence now at hand, be transformed into albuminoids, but they do serve to protect the albuminoids from being consumed. Both albuminoids and gelatinoids, after they have served as building material, can be broken up and oxidized within the body. In this cleavage and oxidation they serve as fuel.

Still another function of the protein is the formation of fats and carbohydrates. These latter are produced by the cleavage of the molecules of the proteid compounds. It is reasonably certain that the albuminoids, and probable, or at any rate possible, that the gelatinoids also, are thus transformed in the animal organism. Similar processes appear to take place in non-living protein compounds (e. g., cheese) under the influence of ferments.

The nitrogenous extractives can neither build tissue nor serve as fuel, but they are useful otherwise. Just how they are useful is not yet fully explained, but they appear to exert some influence upon the nervous system, to act as stimulants, and thus to help the body to make use of other materials in its nourishment.

The amids do not appear to serve any purpose as building material in the animal body. Like the nitrogenous extractives, they are products of the cleavage of the more highly organized proteids. But while they do not appear to be used for either building or repair, they, or some of them at least, serve as fuel, and it is possible that they may, like the gelatinoids, help to protect the albuminoids of the food and of the body tissues from being consumed.

The albuminoids are the most important of the protein compounds, both because they are the only ones that are actually used for building material and because they make up the bulk of the protein of the food and of the body. Gelatinoids and nitrogenous extractives occur only in such animal tissues as muscle, tendon, etc., and their quantity in these is small. The amids are found in considerable quantities in tubers, as potatoes; in roots, as turnips and beets, and in fruits; they are not found to any extent in other food materials. Since the quantities of gelatinoids, nitrogenous extractives, and amids in our food materials are so small, we do not go far astray in following the ordinary practice of using the term protein to denote the building material of the food.¹

FUEL—FUNCTIONS OF FATS AND CARBOHYDRATES.

The machine needs fuel. Starch and sugar are burned in the body and yield heat and power, just as truly as does the coal which is burned

¹ See also pp. 44-49.

in a stove to heat the house or under a boiler to drive an engine. The fats serve the same purpose, only they are more concentrated fuel than the carbohydrates. The body transforms the carbohydrates into fat, which it keeps as a reserve of fuel in the most concentrated form. While the fat of the food is consumed more or less directly, part of it is stored as fat in the body. At the same time the previously stored body fat is being drawn upon for use as fuel. The carbohydrates of the food are consumed more or less directly in the body. Small quantities are transformed into fat, as above stated, and other quantities, probably in most cases still smaller, appear to be transformed into the carbohydrates of the body. The quantity of carbohydrates in the body is at most quite small. The principal one is glycogen. Inosit, which was formerly reckoned with the carbohydrates, is found to have a different constitution, and to contain a benzene nucleus.

The fats and carbohydrates are not the only materials that can be used as fuel. The protein compounds can perform the same service. A dog can live on lean meat, which thus serves as both building material and fuel. We can likewise use the protein of our bodies to supply us with both heat and muscular strength. This last statement may be expressed in another form so as to emphasize an important difference between the protein and the other ingredients of food and between the animal machine and other machines. The protein compounds can do the work of the carbohydrates and fats in being consumed for fuel, but the carbohydrates and fats can not do the work of protein in building and repairing the tissues of the body.

The bodily machine is made of protein. That is to say, blood, muscle, tendon, bone, and brain, all consist of, or at least contain, protein compounds. These are formed from the myosin of meat and fish, the casein of milk, the albumen of eggs, the gluten of wheat, and other albuminoids of the food. As the muscles and other tissues are used up in bodily activity, the same materials of the food are used for their repair. Of course, the mineral matters have a good deal to do with the building up of the tissues. Thus, phosphate of lime is an essential ingredient of the bones.

The chief fuel materials of the bodily machine are carbohydrates and fats, but the protein of the food and the tissues also serves as fuel.

The animal machine differs from others in that it can use its own substance for fuel.

THE POTENTIAL ENERGY OF FOOD—FUEL VALUE.

Heat and muscular power, like mechanical power, light, and electricity, are forms of energy. The energy is latent in the food, and is developed as the food is consumed in the body. We call it potential energy, and measure its quantity as we measure quantities of heat or of mechanical power. In other words, the value of food for fuel is expressed in terms of potential energy. The quantities of potential

energy in food materials are determined by the calorimeter. The unit commonly used is the calorie,¹ the amount of heat which would raise the temperature of a kilogram of water 1° C. (or 1 pound of water 4° F.). Instead of this unit of heat we may use a unit of mechanical energy, for instance, the foot-ton, which is the force that would lift 1 ton 1 foot. One calorie corresponds very nearly to 1.53 foot-tons.

Taking ordinary food materials as they come, the following general estimate has been made for the average fuel value of one gram of each of the classes of nutrients:

Fuel values of nutrients of food.

	Calories.	Foot-tons.
In 1 gram of protein.....	4.1	6.3
In 1 gram of fats.....	9.3	14.2
In 1 gram of carbohydrates.....	4.1	6.3

These figures mean that when a gram of fat, be it the fat of food or body fat, is consumed in the body, it will, if its potential energy be transformed into heat, yield enough to warm $9\frac{3}{10}$ kilograms of water 1° C. (or 4 pounds of water 1° F.); or, if it be transformed into mechanical energy, such as the steam engine or the muscles use to do their work, it will furnish as much as would raise 1 ton $14\frac{1}{5}$ feet, or $14\frac{1}{5}$ tons 1 foot. A gram of protein or carbohydrates would yield a little less than half as much energy as a gram of fat.

It must be remembered that we are to-day only at the beginning of our knowledge of these subjects, and a very large amount of the most laborious, painstaking, and abstract inquiry will be needed to tell satisfactorily what needs to be known. But we are doubtless warranted in using these figures with the distinct understanding that they are tentative and subject to such revision as future research shall indicate. In other words, when we compare the nutrients in respect to their fuel values, their capacities for yielding heat and mechanical power, an ounce of protein of lean meat or albumen of egg is just about equivalent to an ounce of sugar or starch; and a little over 2 ounces of either would be required to equal an ounce of the fat of meat or butter or the body fat. The potential energy in the ounce of protein or carbohydrates would, if transformed into heat, suffice to raise the temperature of 113 pounds of water 1° F., while an ounce of fat, if completely burned in the body or in the calorimeter, would yield as much heat as would warm over twice that weight of water 1°.

¹The same word "calorie" is used to designate the heat required to raise the temperature of a gram of water a degree. The large Calorie is commonly spelled with a capital "C." One Calorie is thus equal to 1,000 calories. It does not seem necessary, however, to maintain this distinction at all times, and the spelling "calorie" will be used for the large Calorie in this publication.

The figures for fuel value in the tables of composition of food materials beyond are calculated for each material by multiplying the number of grams of protein and of carbohydrates in 1 pound (1 pound equals 453.6 grams) by 4.1 and the number of grams of fat by 9.3, and taking the sum of these three products as representing the number of calories in a pound of the material. The figures for fuel value in the dietaries beyond are computed in like manner.

The methods and results of experimental inquiry regarding this general subject will be referred to again.

The functions of food and its nutrients may be briefly summarized as follows:

WAYS IN WHICH FOOD IS USED IN THE BODY.

Food supplies the wants of the body in several ways. It either (1) is used to form the tissues and fluids of the body; (2) is used to repair the wastes of tissues; (3) is stored in the body for future consumption; (4) is consumed as fuel, its potential energy being transformed into heat or muscular energy or other forms of energy required by the body; or, (5) in being consumed protects tissues or other food from consumption.

USES OF THE DIFFERENT CLASSES OF NUTRIENTS.

Protein forms tissue (muscle, tendon, etc., and fat) and serves as fuel.	} All yield energy in form of heat and muscular strength.
Fats form fatty tissue (not muscle, etc.) and serve as fuel.	
Carbohydrates are transformed into fat and serve as fuel.	

In being themselves burned to yield energy, the nutrients protect each other from being consumed. The protein and fats of body tissue are used like those of food. An important use of the carbohydrates and fats is to protect protein (muscle, etc.) from consumption.

DEFINITION OF FOOD.

In this view food may be defined as material which, when taken into the body, serves to either form tissue or yield energy, or both. This definition includes all the ordinary food materials, since they both build tissue and yield energy. It includes sugar and starch, because they yield energy and form fatty tissue. It includes alcohol, because the latter is burned to yield energy, though it does not build tissue. It excludes creatin, creatinin, and other so-called nitrogenous extractives of meat, and likewise thein or caffein of tea and coffee, because they neither build tissue nor yield energy, although they may, at times, be useful aids to nutrition.

CHAPTER III.

COMPOSITION OF FOOD MATERIALS.

Nearly all of our definite knowledge of the chemical composition of food materials and their nutritive values has accumulated within comparatively few years. Yet so active has been the inquiry, especially in the last one or two decades, that the data are to-day quite extensive.

HISTORICAL DEVELOPMENT OF FOOD ANALYSIS.

The first effective impulse to the systematic investigation of the chemistry of food was given by Liebig. It was he who distinguished clearly between the different constituents and indicated their several uses in nutrition. He attributed relatively more importance to the nitrogenous ingredients than later research has justified. He taught that they are the chief sources of muscular force, a doctrine which few would accept to-day. But in the main his classification of the nutrients and their functions has stood the severe test of forty years of experiment and criticism. In the hands of his followers the methods of analysis have been developed and more accurate distinctions have been made between different classes of ingredients. The individual compounds and the changes they undergo in the plant and in the animal have been studied and, with the rapid spread of research in organic, physiological, and agricultural chemistry, in physiology, and in bacteriology, new fields of inquiry have been opened up and research is being pushed forward with great activity.

An adequate historical view of the subject would hardly be in place here. The progress may be clearly seen by referring to the works on food and nutrition which have been the standards at various epochs, beginning with the early editions of Liebig's works on physiological and agricultural chemistry which appeared in 1842 and succeeding years, and including Dietrich and König's magnificent compilations of the results of investigations upon composition and digestibility of feeding stuffs for domestic animals¹ and König's equally valuable compilation regarding the foods and food adjuncts used by man.²

The compilations just referred to illustrate most strikingly the accumulation of data in Europe during comparatively few years. The first edition of Dietrich and König's compilation of analyses of feeding stuffs

¹Dietrich and König. *Zusammensetzung und Verdaulichkeit der Futtermittel*. Zweite Auflage; Bde. I and II; Berlin, 1891.

²J. König. *Chemie der menschlichen Nahrungs- und Genussmittel*. Dritte Auflage; Bde. I and II; Berlin, 1889-1893.

was published in 1874. It is a thin volume of between 90 and 100 pages, consisting mostly of tabular statements of results of analyses with references to the original publications, and very brief comments. The second edition, seventeen years after, likewise in quarto form, is in two volumes. These contain 1,433 pages. Nearly the whole is devoted to statements, mostly in figures, of results of analyses and of experiments upon digestibility of feeding stuffs.

König's compilation regarding the chemistry of materials used as the food of man has lately reached its third edition. The first volume contains 1,189 pages. Introductory statements fill 184 pages of this volume; the rest is devoted to tabular statements of results of analyses and brief comments. The second volume includes 1,401 pages, and is devoted mainly to detailed descriptions of the different kinds of food materials.

While it is hardly possible to exaggerate the value of these monuments of German painstaking scholarship, they are very far from meeting the needs of English-speaking people, especially in the United States, not only because they are in the German language and written for German readers, but also because much that people in this country who are interested in such matters want to know is not contained in them. Our food materials, our habits of food consumption, and our food production all differ to a greater or less extent from those in Germany, and we need information fitted to our special circumstances.

It would be hardly proper to omit from even so brief an account of the development of food analysis as this a reference to what has been done since the introduction of the so-called Weende method, of which the late Professor Henneberg was the author. This dates practically from the year 1864, at which time a plan for methods for analysis of feeding stuffs was presented at the second Convention of German Agricultural Chemists.¹

As long ago as 1836 Boussingault reported analyses² of a number of feeding stuffs, laying especial stress upon the quantities of nitrogen. In 1831 Boussingault and Le Bel reported analyses of milk.³ The methods, however, were quite imperfect. For a number of years the chief stress was laid upon the quantities of carbon and nitrogen. Even in the works of Payen, as late as 1865, the simpler methods which took into account little else than the water, nitrogen, and carbon were followed, although more or less effort was made to determine the quanti-

¹Landw. Vers. Stat., 6, 496.

²Recherches sur la Quantité d'Azote contenue dans les Fourrages, et sur leurs Équivalens; par M. Boussingault. Ann. Chim. et Phys., vol. 63, p. 225, 1836. Recherches sur la Quantité d'Azote contenue dans les Fourrages, et sur leurs Équivalens; par M. Boussingault. Ann. Chim. et Phys., vol. 67, p. 408, 1838. Ibid., 68, p. 408.

³Recherches sur l'Influence de la Nourriture des Vaches, sur la Quantité et la Constitution chimique du Lait; par MM. Boussingault et Le Bel. Ann. Chim. et Phys., vol. 71, p. 65, 1839.

ties of fats and to distinguish between the different nitrogenous compounds, as well as the carbohydrates.¹

A distinct advance is found in some of the publications between 1840 and 1864, but it was not until the Weende method came into use and compilations of results of analyses made in accordance with it had become current that chemists generally adopted the forms which are now in general use.

ANALYSES OF AMERICAN FOOD PRODUCTS.

The first analyses made by these modern methods in the United States were a series of analyses of Indian corn by the writer under the direction of Prof. S. W. Johnson in New Haven in 1869.²

With the exception of the excellent work by Professor Storer at the Bussey Institution, comparatively little was done in this direction until the establishment of the experiment stations. The station at Middletown, Conn., made a number of analyses in the years 1877-1879. Others followed in rapid succession, though nearly all of the attention was given to feeding stuffs. The compilation of analyses of American feeding stuffs by Jenkins and Winton,³ which "was designed to include all analyses published before September 1, 1890," and does include very nearly all, contains results of examinations of 3,267 specimens. The condensed tabular compilation of these fills 138 pages.

The compilation just referred to contains very few analyses of materials used as the food of man, and it is not until within a short time past that much attention has been given to this particular branch of investigation. A large number of analyses, indeed, have been made of milk, butter, and cheese, but the purpose of these has been mainly agricultural. A considerable number of analyses of fruits and vegetables have also been made by the Bussey Institution, the Division of Chemistry of the United States Department of Agriculture, and the Maine, Massachusetts, Connecticut, New York, Tennessee, California, and other experiment stations. The first at all extended series of examinations of materials used as food from the standpoint of their nutritive value for man in the United States was a study of American fishes and the invertebrates. This was undertaken at the instance and partly at the expense of the Smithsonian Institution and the United States Fish Commission through the influence of the late Prof. S. F. Baird. The work was performed in the chemical laboratory of Wesleyan University under the direction of the writer. In connection with this, at the instance of the United States National Museum, a series of analyses of American meats was undertaken. These investigations were carried out during the years 1878-1891, and included analyses of

¹ See, for instance, *Substances Alimentaires*. Payen, 1865.

² *Am. Jour. Sci.*, vol. 48, 1869, p. 352.

³ *A Compilation of Analyses of American Feeding Stuff*s, by E. H. Jenkins, Ph. D., and E. L. Winton, Ph. B. U. S. Dept. Agr., Office of Experiment Stations, Bul. No. 11. Washington, 1892.

the flesh of some 200 specimens of sea and fresh-water fishes, oysters, clams, etc., and of nearly 100 specimens of meats. A few analyses of milk, butter, cheese, flour, bread, etc., were also included. The results of the analyses of fishes and the invertebrates have been published by the United States Commission of Fish and Fisheries,¹ those of meats and vegetable foods were published by the Storrs (Conn.) Experiment Station.²

The number of analyses of dairy products in the United States has grown to be very large—so large indeed that complete compilation would be extremely difficult and perhaps of doubtful value.

A considerable number of specimens of materials used for the food of man, especially of canned vegetables, have been made in the Division of Chemistry of the Department of Agriculture under the direction of Prof. H. W. Wiley.³ Quite a number of analyses have also been made in connection with the studies of adulteration of foods in the same laboratory. Some years previous a considerable number of analyses of specimens of American flour and the bread made from them were made in the same laboratory by Mr. Clifford Richardson.⁴

A series of analyses of milling products of wheat was made by Professor Kedzie in Michigan some years ago.⁵

In his report on cereals, which was published in the volume on agriculture of the Report of the United States Census for 1880, Prof. W. H. Brewer has given analyses of a number of cereal products. During the years 1890–1894, in connection with studies of dietaries by the Storrs (Conn.) Experiment Station, a number of analyses of food materials have been made. These, however, have been published only in part.

The collection of food materials at the World's Fair at Chicago, in 1893, offered an unusually favorable opportunity for obtaining specimens for chemical examination. This fact was appreciated by the World's Columbian Commission, and Prof. H. W. Wiley, of the United States Department of Agriculture, was called upon by the Bureau of Awards of that Commission to execute analyses of a large number of specimens of grains and milling products from them. These investigations are being continued in the chemical laboratory of that Department, and are not fully completed at the time of this writing.

At the same time the writer was invited by the Bureau of Awards to make examinations of such other food materials as seemed advisable. The remarkably favorable occasion for securing specimens of meats and meat products as prepared at the great slaughtering establishments in Chicago was also utilized. Some 500 such specimens of food materials

¹The Chemical Composition and Nutritive Values of Food-Fishes and Aquatic Invertebrates, by W. O. Atwater, Ph. D. Report U. S. Commissioner of Fish and Fisheries, 1888. Washington, 1891.

²W. O. Atwater and C. D. Woods. Reports Storrs (Conn.) Experiment Station, 1891, 1892, and 1893, *passim*.

³Bull. 13, Div. Chem., U. S. Dept. Agr., pp. 1015–1167.

⁴Bull. 4, Div. Chem., U. S. Dept. Agr.

⁵Rept. Mich. Bd. Agr., 1877, p. 350.

from the exhibits by the various nations at the fair in Chicago and from the slaughtering establishments in the city were collected and analyzed. Part of the work was done in Chicago during the fair, and the rest was completed later in the chemical laboratory of Wesleyan University, in connection with the work of the Storrs Station, which is conducted there. The results of these analyses still await publication.

TABLES OF COMPOSITION OF AMERICAN FOOD MATERIALS.

The compilation of the results of analyses of American food materials up to the present time is greatly to be desired. An effort in this direction is already begun, but the results are not yet ready for publication. Tables 1 and 2, which follow, give a summary of the results thus far published. It is essentially the same as that published in the report of the Storrs (Conn.) Experiment Station for 1891.¹ To the figures there given have been added the results of examinations of specimens of canned vegetables by Professor Wiley and his assistants which were previously mentioned.

It will be observed that the table gives in the first column the number of analyses of specimens of each kind of material. In a large number of cases only a single analysis had been made at the time, or at any rate had been found by us at the time when the table was prepared. In other cases, several analyses are available. Where more than one analysis has been made, the maximum, minimum, and averages are given. It should be explained, however, that the figures for maximum and minimum indicate the largest or smallest percentage of each ingredient found in any case, so that the figures for maximum or minimum of a given material do not all refer to the same specimen.

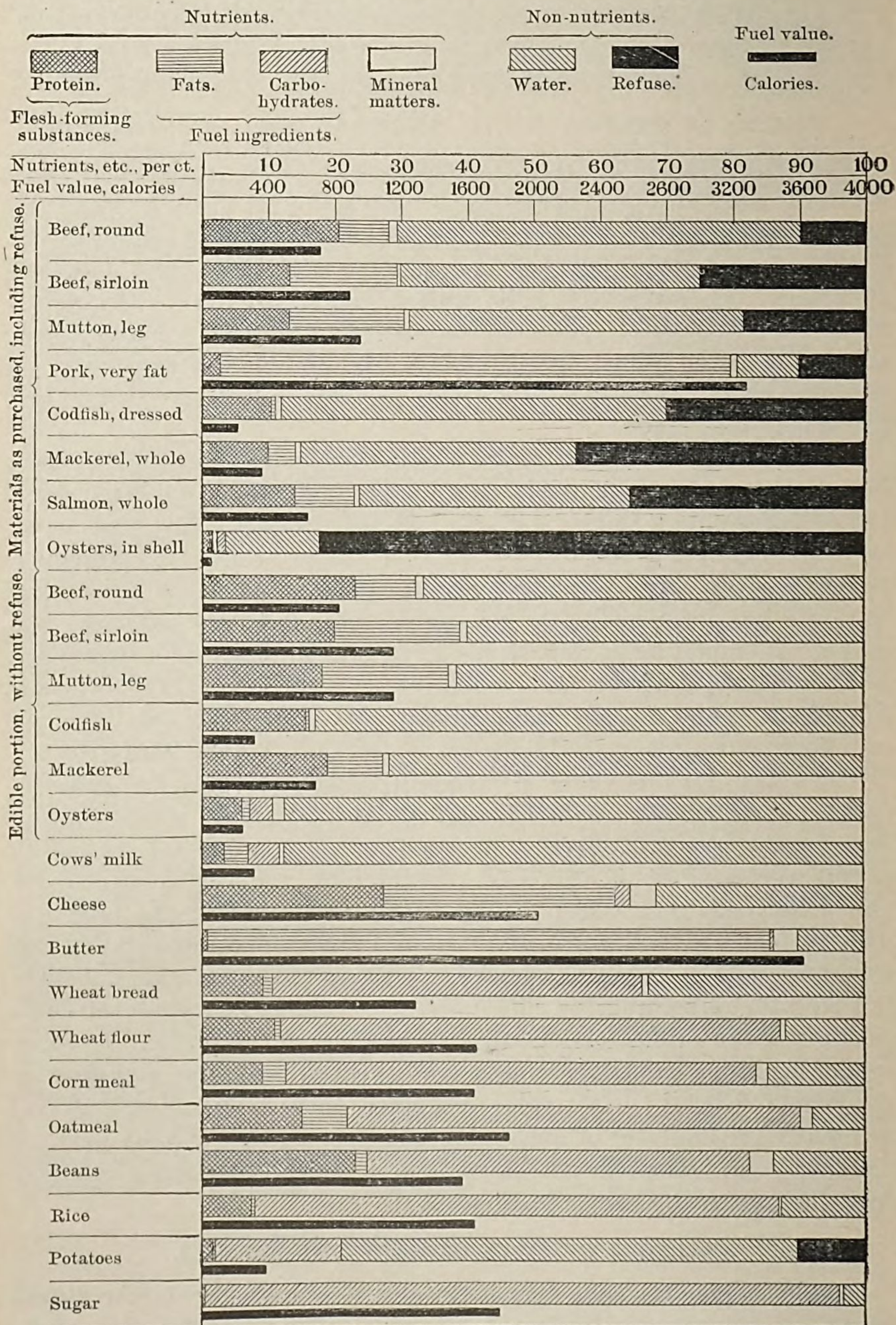
The figures for fuel value give the estimated calories in the protein, fats, and carbohydrates in 1 pound of the material. These figures are not the result of direct determinations, but are found by multiplying the number of grams of protein, fats, and carbohydrates by the factors 4.1, 9.3, and 4.1, respectively, and adding the products as explained above. (See p. 15.) Table 1 gives the composition of the food materials as they are ordinarily purchased in the markets, including both the refuse and the edible portion, while Table 2 gives the composition of the edible portion after the removal of the refuse. In some animal foods, as milk, cheese, and oysters (shell contents), and most of the vegetable foods (such as flour and bread) there is no refuse, and consequently the analyses of such materials appear, for the most part, in Table 2 alone. The relative composition of a small number of common foods is graphically shown in Chart 1.

ANALYSES OF SIDES OF BEEF AND MUTTON.

People in general have very little idea how wide may be the differences in composition of different specimens of meat of the same kind, as, for instance, beef from different animals and different cuts of beef

¹The Composition of Food Materials. By W. O. Atwater and Chas. D. Woods.

CHART 1.—COMPOSITION OF FOOD MATERIALS.

Nutritive ingredients, refuse, and fuel value.

from the same animal. These differences are illustrated in the analyses in Tables 1 and 2 below, and still more forcibly in Tables 3 to 10¹ and in fig. 1.

COMPOSITION OF SIDE OF BEEF.

Tables 3 to 6 give results of analyses of a side of beef which was butchered in Chicago and sold in Middletown, Conn. The side was called by the dealer in Middletown an average one as regards weight and fatness, etc. Its total weight at the car in the station at Middletown, where it was received, was 326 pounds, the fore quarter weight 176 pounds, and the hind quarter 150 pounds. It will be noticed in Table 6 that the sums of the weights of the individual cuts make the side weigh 317.6 pounds, and that the falling off in weight was almost wholly in the hind quarter, which weighed 150 pounds at the car and

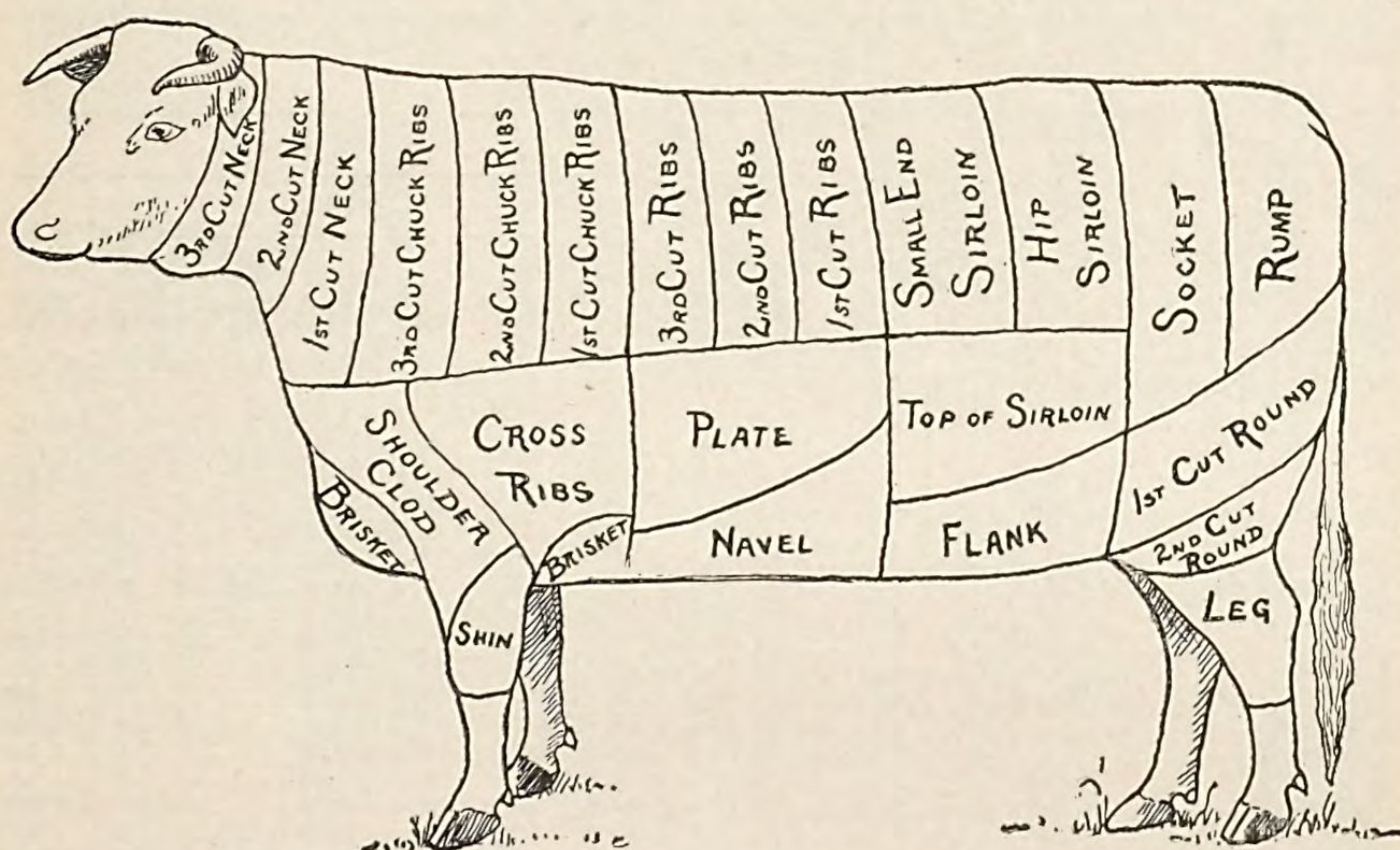


FIG. 1.—Diagram of cuts of beef.

by individual cuts only 142 pounds. The side, when received, was partly frozen, and the fore quarter was analyzed first. These two facts may account for the shrinkage in the weight of the hind quarter, which was kept for a longer time before the analyses were made. The cuts were made in accordance with the usage in New York markets, and are shown in the diagram herewith.

The fore quarter was thus divided into 15 and the hind quarter into 9 cuts. Each cut was weighed and a portion taken for analysis. The edible portion (flesh) and the refuse (bone, gristle, etc.) were separated and each weighed by itself. Table 3 shows the composition of the water-free substance of the edible portion; Table 4 the composition of the flesh (edible portion), and Table 5 the composition of the several cuts and of the whole side, including both refuse and edible portion.

¹ Taken from Report Storrs (Conn.) Experiment Station above referred to, pp. 59-65.

In Table 6 the results of the analyses of the whole side and the several cuts, which in Table 5 are represented in percentages, are calculated into pounds, so as to give the actual weights of the several ingredients in the different cuts and in the whole.

COMPOSITION OF SIDE OF MUTTON AND SIDE OF LAMB.

The side of mutton was from a Connecticut-grown sheep, 2 years old, of about medium fatness. One whole side was taken for analysis, the different cuts being made in the usual manner as specified in the tables.

The side of lamb was from a Connecticut-grown lamb 6 months old. The dressed weight was about 39 pounds. It was above rather than below medium fatness. The plan of the tables is the same as those for the side of beef.

TABLE 1.—*Composition of food materials as found in the markets, including both edible portion and refuse.*

Food materials		Num- ber of analy- ses.	Salt.	Refuse (bones, skin, shell, etc.).	Edible portion.						Fuel value of 1 pound.
					Water.	Nutrients.					
						Total.	Pro- tein.	Fat.	Car- bohy- drates.	Min- eral mat- ters.	
MEATS, ETC.											
Beef:			<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>Calo- ries.</i>	
Neck.....	{ Min ..	3	.....	18.4	47	28.9	14.9	11.8	.....	800	
	{ Max ..	3	.....	22.9	52.4	32.1	16.2	16.4	.....	970	
	{ Avg ..	3	.....	20	49.6	30.4	15.6	14	.....	880	
Chuck ribs.....	{ Min ..	8	.....	5.4	42.7	30.4	13.5	13.3	.....	865	
	{ Max ..	8	.....	19.7	59.7	44.6	16.4	28.6	.....	1,490	
	{ Avg ..	8	.....	14.6	49.5	35.9	15	20.1	.....	1,125	
Ribs.....	{ Min ..	4	.....	19.4	26.3	39.7	11.3	26.5	.....	1,360	
	{ Max ..	4	.....	22.7	40.2	42.3	13	29.2	.....	1,460	
	{ Avg ..	4	.....	21	38.2	40.8	12.2	27.9	.....	1,405	
Brisket.....		1	.....	14.3	40.6	45.1	12.5	31.9	.....	1,580	
Cross ribs.....		1	.....	12.2	38.6	49.2	12	36.5	.....	1,765	
Shoulder.....	{ Min ..	6	.....	10.7	49.9	27	14.8	8.8	.....	695	
	{ Max ..	6	.....	15.6	60.6	38.8	18.6	19.2	1	1,155	
	{ Avg ..	6	.....	12.6	55.8	31.6	17	15.7	.....	895	
Shin.....		1	.....	40.1	44.2	15.7	13.6	1.4	.....	310	
Plate.....		1	.....	17.9	36.4	45.7	12.6	32.4	.....	1,600	
Navel.....		1	.....	11.4	42.2	46.4	13.4	32.3	.....	1,610	
Sirloin.....	{ Min ..	4	.....	13	42.8	29.7	12.5	14	.....	920	
	{ Max ..	4	.....	27.3	52.6	35	19.1	18.7	1.2	1,075	
	{ Avg ..	4	.....	19.5	48.3	32.2	15	16.4	.....	970	
Socket.....		1	.....	35.8	36.7	27.5	10.7	16.1	.....	880	
Rump.....	{ Min ..	2	.....	6.5	33.7	40.9	12.3	25.1	.....	1,340	
	{ Max ..	2	.....	16.2	52.6	50.1	15	37.2	.....	1,800	
	{ Avg ..	2	.....	11.3	43.2	45.5	13.7	31.1	.....	1,570	
Round, first cut.....		1	.....	7.8	60.9	31.3	18	12.3	1	855	
Round, second cut.....		1	.....	32.1	47.2	20.7	14	5.8	.....	505	
Leg.....		1	.....	62.2	27.3	10.5	7.9	2.1	.....	235	
Top of sirloin.....		1	.....	3.2	40.9	55.9	12.9	42.3	.....	2,025	
Flank.....		1	.....	11.5	24.3	64.2	10.6	53	.....	2,435	
Fore quarter.....			.....	18.5	44.1	37.4	14.1	22.5	.....	1,210	
Hind quarter.....			.....	20.2	44.4	35.4	13.6	21	.....	1,140	
Side without kidney fat.....			.....	19.2	44.3	36.5	13.9	21.8	.....	1,180	
Veal:											
Shoulder.....		1	.....	11.5	63.7	24.8	18.3	5.5	1	570	
Shoulder and flank.....		1	.....	24.3	49.7	26	14.9	10.2	.....	715	
Mutton:											
Shoulder.....		1	.....	16.3	49	34.7	15.1	18.8	.....	1,075	
Breast.....		1	.....	14.9	32	53.1	12.1	40.1	.....	1,915	
Neck.....		1	.....	27.6	40.3	32.1	11.7	19.8	.....	1,055	
Rack.....		1	.....	19.3	44.3	36.4	14.9	20.9	.....	1,160	
Leg.....		1	.....	18.1	50.6	31.3	15	15.6	.....	935	
Loin.....		1	.....	15.8	41.5	42.7	12.6	29.5	.....	1,480	
Flank.....		1	.....	2.1	37.9	60	15.4	44.1	.....	2,145	
Fore quarter.....			.....	19	42.3	38.7	13.7	24.2	.....	1,275	
Hind quarter.....			.....	15.7	46.1	38.2	14.3	23.2	.....	1,245	
Side without kidney fat.....			.....	17.3	44.2	38.5	14	23.7	.....	1,260	

TABLE 1.—Composition of food materials as found in the markets, etc.—Continued.

Food materials.	Number of analyses.	Salt.	Refuse (bones, skin, shell, etc.).	Edible portion.						Fuel value of 1 pound.
				Water.	Nutrients.					
					Total.	Protein.	Fat.	Carbohydrates.	Mineral matters.	
MEATS, ETC.—continued.										
Lamb:		<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>Calo-ries.</i>
Shoulder.....	1	.....	20.3	41.3	38.4	14	23.6	.....	.8	1,255
Breast.....	1	.....	19.1	45.5	35.4	15.5	19.1	.....	.8	1,095
Neck.....	1	.....	17.7	46.7	35.6	14.4	20.4	.....	.8	1,130
Leg.....	1	.....	17.7	53.3	29	15.5	12.6	.....	.9	820
Loin.....	1	.....	12.2	48.1	39.7	16.7	22.1	.....	.9	1,245
Fore quarter.....	.....	.....	18.8	44.7	36.5	14.7	21	.....	.8	1,160
Hind quarter.....	.....	.....	15.7	51.3	33	16	16.1	.....	.9	975
Side without kidney fat.....	.....	.....	17.3	47.9	34.8	15.3	18.6	.....	.9	1,070
Pork:										
Shoulder roast.....	{ Min..	4	7.1	38.8	39.6	13.2	25.4	.....	.7	1,325
	{ Max..	4	20.3	49.4	45.9	14.1	28.9	.....	.8	1,590
	{ Avg..	4	14.6	43	42.4	13.6	28	.....	.8	1,435
Poultry, etc.:										
Chicken.....	1	.....	38.2	44.6	17.2	15.1	1.2	.....	.9	330
Turkey.....	1	.....	32.4	44.7	22.9	16.1	5.9	.....	.9	550
Hens' eggs in shell	{ Min..	2	13.4	62.3	22.7	12.1	9.7	.....	.8	635
	{ Max..	2	13.9	63.9	23.8	12.2	10.8	.....	.9	680
	{ Avg..	2	13.7	63.1	23.2	12.1	10.2	.....	.9	655
Preserved meats:										
Corned beef, rump.....	1	.....	5	70.8	24.2	16.7	5.1	.....	2.4	525
Corned beef, flank	{ Min..	2	9.6	39	37.1	11.7	21.2	.....	2.5	1,140
	{ Max..	2	14.6	48.3	51.4	13.2	37.2	.....	2.7	1,785
	{ Avg..	2	12.1	43.7	44.2	12.4	29.2	.....	2.6	1,460
Ham, salted and smoked..	1	.....	11.4	36.8	51.8	14.8	34.6	.....	2.4	1,735
FISH, SHELLFISH, ETC.										
Fresh fish:										
Sturgeon, section.....	1	.....	14.4	67.4	18.2	15.4	1.6	.....	1.2	355
Red-horse, entrails re- moved.....	1	.....	52.5	37.3	10.2	8.5	1.1	.....	.6	205
Herring, whole.....	1	.....	46	37.3	16.7	10	5.9	.....	.8	435
Alewife, whole.....	{ Min..	2	49.4	36.9	12.2	9.5	1.9	.....	.8	255
	{ Max..	2	49.5	38.3	13.7	9.9	3	.....	.8	310
	{ Avg..	2	49.5	37.5	13	9.7	2.5	.....	.8	285
Shad, whole.....	{ Min..	7	44.4	30.3	10.9	7.4	2.9	.....	.6	260
	{ Max..	7	58.8	39.5	18.6	10.5	7.3	.....	.8	505
	{ Avg..	7	50.1	35.2	14.7	9.2	4.8	.....	.7	375
Smelt, whole.....	{ Min..	2	34.8	39.9	11.1	9.6	.8	.....	.7	215
	{ Max..	2	49	52.3	12.9	10.4	1.2	.....	1.3	245
	{ Avg..	2	41.9	46.1	12	10	1	.....	1	230
Whitefish, whole.....	1	.....	53.5	32.5	14	10.3	3	.....	.7	320
Ciscoe, whole.....	1	.....	42.7	43.6	13.7	11	2	.....	.7	290
California salmon, section	{ Min..	2	.....	57.9	31.8	16.1	14.8	.....	.9	925
	{ Max..	2	10.3	62.7	37.3	17	19.2	.....	1.1	1,125
	{ Avg..	2	5.2	60.3	34.5	16.5	17	.....	1	1,025
Salmon, whole.....	{ Min..	4	30.8	36.9	23.6	13.3	7.9	.....	.9	610
	{ Max..	4	39.5	45	24.3	15.2	10	.....	1	670
	{ Avg..	4	35.3	40.6	24.1	14.3	8.8	.....	1	635
Salmon, entrails removed..	1	.....	23.8	51.2	25	14.6	9.5	.....	.9	675
Lake trout, whole.....	1	.....	56.3	30	13.7	7.7	5.4	.....	.6	370
Lake trout, entrails re- moved.....	1	.....	35.2	45	19.8	12.4	6.6	.....	.8	510
Brook trout, whole	{ Min..	3	45.2	38.6	11	9.2	.4	.....	.5	225
	{ Max..	3	59.1	43.8	12.3	10.2	1.5	.....	.7	255
	{ Avg..	3	48.1	40.4	11.5	9.8	1.1	.....	.6	230
Pickrel, whole.....	{ Min..	2	45.4	40.8	10.5	9.7	.2	.....	.6	190
	{ Max..	2	48.7	43.6	11	10	.3	.....	.7	200
	{ Avg..	2	47.1	42.2	10.7	9.8	.2	.....	.7	195
Pike, whole.....	1	.....	42.7	45.7	11.6	10.7	.3	.....	.6	210
Muscalonge, whole.....	1	.....	49.2	38.7	12.1	10	1.3	.....	.8	240
Eel, salt water, dressed	{ Min..	2	19	54.9	21.6	14.3	6.4	.....	.7	535
	{ Max..	2	21.4	59.4	23.7	14.9	8.1	.....	.9	620
	{ Avg..	2	20.2	57.2	22.6	14.6	7.2	.....	.8	575
Mul'et, whole.....	1	.....	57.9	31.5	10.6	8.1	2	.....	.5	235
Mackerel, whole.....	{ Min..	5	33.8	35.8	12.2	8.4	1.4	.....	.6	300
	{ Max..	5	57.9	48.5	23.8	12.1	10.7	.....	1	675
	{ Avg..	5	44.6	40.4	15	10	4.3	.....	.7	370
Mackerel, entrails removed..	1	.....	40.7	43.7	15.6	11.4	3.5	.....	.7	360
Spanish mackerel, whole.....	1	.....	34.6	44.5	20.9	13.7	6.2	.....	1	515
Pompano, whole.....	{ Min..	2	42.4	38.8	11.2	9.9	.8	.....	.5	220
	{ Max..	2	48.6	40.2	18.8	10.5	7.8	.....	.5	525
	{ Avg..	2	45.5	39.5	15	10.2	4.3	.....	.5	370

TABLE 1.—Composition of food materials as found in the markets, etc.—Continued.

Food materials.	Num- ber of analy- ses.	Salt.	Refuse (bones, skin, shell, etc.).	Edible portion.						Fuel value of 1 pound.	
				Water.	Nutrients.						
					Total.	Pro- tein.	Fat.	Car- bohy- drates.	Min- eral mat- ters.		
FISH, SHELLFISH, ETC.—cont'd.											
Fresh fish—Continued.		<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>Calo- ries.</i>	
Bluefish, entrails removed.	1	.....	48.6	40.3	11.1	9.8	.6	.....	.7	205	
Butter-fish, whole.	1	.....	42.8	40.1	17.1	10.2	6.3	.....	.6	455	
Black bass, whole.	2	.....	53.6	34.6	9.4	8.5	.4	.....	.5	175	
	2	.....	56	34.7	11.7	10	1.1	.....	.6	230	
	2	.....	54.8	34.6	10.6	9.3	.8	.....	.5	205	
Yellow perch, whole.	1	.....	62.7	30	7.3	6.7	.2	.....	.4	135	
Yellow perch, dressed.	1	.....	35.1	50.7	14.2	12.6	.7	.....	.9	265	
Wall-eyed pike, whole.	1	.....	57.2	34.1	8.7	7.9	.2	.....	.6	155	
Gray pike, whole.	1	.....	63.2	29.7	7.1	6.4	.3	.....	.4	130	
Striped bass, whole.	5	.....	48.6	32.5	8.7	7.2	.7	.....	.5	170	
	5	.....	57.1	39.7	11.7	9.7	1.6	.....	.6	240	
	5	.....	54.9	35.1	10	8.3	1.1	.....	.6	200	
Striped bass, entrails re- moved.	1	.....	51.2	37.4	11.4	8.7	2.2	.....	.5	255	
White perch, whole.	2	.....	61.8	27.8	9	6.5	1	.....	.4	185	
	2	.....	63.2	28.9	9.3	7.8	2.1	.....	.5	210	
	2	.....	62.5	28.4	9.1	7.2	1.5	.....	.4	195	
Sea bass, whole.	1	.....	56.1	34.8	9.1	8.3	.2	.....	.6	160	
Red grouper, en- trails removed.	2	.....	55.8	34.8	8.9	8.2	.2	.....	.5	160	
	2	.....	55.9	35.3	9.3	8.5	.3	.....	.5	170	
	2	.....	55.9	35	9.1	8.4	.2	.....	.5	165	
Red snapper, whole.	1	.....	40	46.9	13.1	12	.4	.....	.7	240	
Red snapper, en- trails removed.	2	.....	45.3	36.8	10.7	9.2	.3	.....	.6	200	
	2	.....	52.5	43.7	11	10	.9	.....	.7	210	
	2	.....	48.9	40.3	10.8	9.6	.6	.....	.6	205	
Porgy, whole.	3	.....	57.3	27.8	7.1	6.1	.5	.....	.5	135	
	3	.....	65.1	31.1	12	8.2	3.4	.....	.6	295	
	3	.....	60	29.9	10.1	7.4	2.1	.....	.6	225	
Sheepshead, whole.	1	.....	66	26.9	7.1	6.4	.2	.....	.5	125	
Sheepshead, entrails re- moved.	1	.....	56.5	31.3	12.2	8.8	2.9	.....	.5	285	
Red bass, whole.	1	.....	63.5	29.8	6.7	6.1	.2	.....	.4	120	
Kingfish, whole.	1	.....	56.6	34.4	9	8.1	.4	.....	.5	170	
Weakfish, whole.	1	.....	51.9	38	10.1	8.4	1.1	.....	.6	200	
Blackfish, whole.	2	.....	56.2	29.2	6.7	6.3	.2	.....	.2	125	
	2	.....	64.1	33.7	10.1	8.3	1.2	.....	.6	205	
	2	.....	60.1	31.5	8.4	7.3	.7	.....	.4	165	
Blackfish, entrails removed.	2	.....	53.6	33.5	8.7	7.9	.4	.....	.4	165	
	2	.....	57.8	36.4	10	8.7	.7	.....	.6	190	
	2	.....	55.7	35	9.3	8.3	.5	.....	.5	175	
Hake, entrails removed.	1	.....	52.5	39.5	8	7.2	.3	.....	.5	145	
Cusk, entrails removed.	1	.....	40.3	49	10.7	10.1	.1	.....	.5	190	
Haddock, entrails removed.	4	.....	48	38.5	8.6	7.8	.1	.....	.5	150	
	4	.....	52.9	42.9	9.6	8.9	.2	.....	.8	170	
	4	.....	51	40	9	8.2	.2	.....	.6	160	
Cod, whole.	2	.....	48.5	35.1	8.4	7.7	.1	.....	.6	145	
	2	.....	56.5	42.3	9.2	8.3	.3	.....	.6	165	
	2	.....	52.1	38.7	8.8	8	.2	.....	.6	155	
Cod, dressed.	3	.....	25.5	55.3	11	9.9	.2	.....	.8	190	
	3	.....	33.7	62.1	12.4	11.4	.3	.....	.9	220	
	3	.....	29.9	58.5	11.6	10.6	.2	.....	.8	205	
Tomcod, whole.	1	.....	59.9	32.7	7.4	6.8	.2	.....	.4	135	
Pollock, dressed.	1	.....	28.5	54.3	17.2	15.5	.6	.....	1.1	315	
Halibut, sections.	3	.....	11.2	60.9	16	13.4	1.7	.....	.7	320	
	3	.....	22.1	62.6	26.5	16.1	9.4	.....	1	695	
	3	.....	17.7	61.9	20.4	15.1	4.4	.....	.9	465	
Turbot, whole.	1	.....	47.7	37.3	15	6.8	7.5	.....	.7	440	
Flounder, whole.	2	.....	56.2	35.8	6.8	6.1	.2	.....	.5	120	
	2	.....	57	37	7.2	6.3	.3	.....	.6	130	
	2	.....	56.6	36.4	7	6.2	.3	.....	.5	125	
Flounder, entrails removed.	1	.....	57	35.8	7.2	6.3	.3	.....	.6	130	
Lamprey eel, whole.	1	.....	45.8	38.5	15.7	8.1	7.2	.....	.4	455	
Skate, lobe of body.	1	.....	51	40.2	8.8	7.5	.7	.....	.6	170	
Preserved fish:											
Salted mackerel.	1	7.1	33.3	28.1	31.5	14.7	15.1	.....	1.7	910	
Salted cod.	2	17.2	24.3	40	17.2	15.7	.3	.....	1.2	305	
	2	17.3	25.5	40.5	18	16.4	.4	.....	1.2	320	
	2	17.2	24.9	40.3	17.6	16	.4	.....	1.2	315	
Smoked herring.	1	6.5	44.4	19.2	29.9	20.2	8.8	.....	.9	745	
Smoked haddock.	1	1.4	32.2	49.2	17.2	16.1	.1	.....	1	305	
Smoked halibut.	2	12	5.9	44.9	33	16.7	13.6	.....	1.9	920	
	2	12.1	8	47	37.1	21.6	14.4	.....	1.9	975	
	2	12.1	6.9	46	35	19.1	14	.....	1.9	945	

TABLE 1.—Composition of food materials as found in the markets, etc.—Continued.

Food materials.	Num- ber of analy- ses.	Salt.	Refuse (bones, skin, shell, etc.).	Edible portion.						Fuel value of 1 pound.	
				Water.	Nutrients.						
					Total.	Pro- tein.	Fat.	Car- bohy- drates.	Min- eral mat- ters.		
FISH, SHELLFISH, ETC.—cont'd.											
Shellfish, etc.:		<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>Calo- ries.</i>	
Oysters in shell ... { Min ..	34	.....	76.1	9.2	1	.5	.1	.2	.1	.....	
{ Max..	34	.....	88.8	22.8	4.6	2.1	.4	1.3	.7	.....	
{ Avg..	34	.....	82.4	15.3	2.3	1.1	.2	.6	.4	40	
Long clams in shell { Min ..	4	.....	42.1	46.4	7.5	4.4	.5	.9	1.2	120	
{ Max..	4	.....	46.1	49.9	8.5	5.1	.7	1.4	1.6	145	
{ Avg..	4	.....	43.6	48.4	8	4.8	.6	1.1	1.5	135	
Round clams in shell	1	.....	68.3	27.3	4.4	2.1	.1	1.3	.9	65	
Mussels in shell	1	.....	49.3	42.7	8	4.4	.6	2.1	.9	145	
Lobster in shell ... { Min ..	4	.....	47.5	25.1	5.5	4.1	.5	.....	.6	125	
{ Max..	4	.....	69.4	44.3	8.2	6.5	.9	.....	.8	160	
{ Avg..	4	.....	62.1	31.1	6.8	5.4	.7	.....	.7	130	
Crab in shell	1	.....	55.8	34.1	10.1	7.9	.9	.....	1.3	185	
Terrapin in shell	1	.....	79	15.7	5.3	4.4	.7	.....	.2	110	
Green turtle in shell.....	1	.....	76	19.2	4.8	4.4	.1	.....	.3	85	

TABLE 2.—Composition of food materials, edible portion.

Food materials.	Num- ber of analy- ses.	Salt.	Water.	Nutrients.					Fuel value of 1 pound.
				Total.	Pro- tein.	Fat.	Carbo- hy- drates.	Min- eral mat- ters.	
MEATS, ETC.									
Beef:			<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>Calories</i>
Neck.....	{ Min ..	3	60.6	35.5	18.3	14.5		1	985
	{ Max..	3	64.5	39.4	20.2	20.1		1.1	1,190
	{ Avg..	3	62	38	19.5	17.5		1	1,190
Chuck ribs	{ Min ..	8	51.3	33.8	16	14.7		.7	960
	{ Max..	8	66.2	48.7	20.4	32		1.2	1,659
	{ Avg..	8	58	42	17.6	23.5		.9	1,320
Ribs.....	{ Min ..	5	46.2	50.1	14.6	32.9		.8	1,690
	{ Max..	5	49.9	53.8	16.1	37.1		1.1	1,860
	{ Avg..	5	48.1	51.9	15.4	35.6		.9	1,790
Brisket.....		1	47.4	52.6	14.6	37.2		.8	1,840
Cross ribs		1	43.9	56.1	13.7	41.6		.8	2,010
Shoulder.....	{ Min ..	6	56.2	30.8	17.1	10		.9	790
	{ Max..	6	69.2	43.8	21	21.6		1.2	1,309
	{ Avg..	6	63.9	36.1	19.5	15.6		1	1,020
Shin.....		1	73.8	26.2	22.7	2.3		1.2	520
Plate.....		1	44.4	55.6	15.4	39.4		.8	1,950
Navel		1	47.6	52.4	15.1	36.5		.8	1,820
Sirloin.....	{ Min ..	4	58.9	39.3	16.9	16.1		.9	1,090
	{ Max..	4	60.7	41.1	22	22.9		1.4	1,290
	{ Avg..	4	60	40	18.5	20.5		1	1,210
Socket		1	57.1	42.9	16.7	25.2		1	1,375
Rump	{ Min ..	2	40.2	43.7	14.7	26.8		.8	1,430
	{ Max..	2	56.3	59.8	16.1	44.3		.8	2,145
	{ Avg..	2	48.2	51.8	15.4	35.6		.8	1,790
Round	{ Min ..	3	66	30.5	19.5	8.2		1.1	745
	{ Max..	3	69.5	34	21.5	13.4		1.3	936
	{ Avg..	3	68.2	31.8	20.5	10.1		1.2	805
Leg		1	72.1	27.9	21	5.7		1.2	639
Top of sirloin		1	42.2	57.8	13.3	43.7		.8	2,090
Flank		1	27.4	72.6	12	59.9		.7	2,750
Fore quarter			54.1	45.9	17.3	27.7		.9	1,490
Hind quarter.....			55.7	44.3	17.1	26.3		.9	1,430
Side without kidney fat.....			54.8	45.2	17.2	27.1		.9	1,465
Liver.....		1	69.5	30.5	20.1	5.4	3.5	1.5	665
Kidney.....		1	75.7	24.3	17	4.8	1.3	1.2	545
Heart.....		1	56.5	43.5	16.3	26.2		1	1,410
Tongue		1	63.5	36.5	17.4	18		1.1	1,085
Kidney fat		1	4.3	95.7	.9	94.6		.2	4,010
Marrow (leg bone)		1	3.3	96.7	2.6	92.8		1.3	3,965
Veal:									
Shoulder	{ Min ..	2	65.6	28	19.7	6.1		1.2	640
	{ Max..	2	72	34.4	20.7	13.5		1.2	935
	{ Avg..	2	68.8	31.2	20.2	9.8		1.2	790

TABLE 2.—Composition of food materials, edible portion—Continued.

Food materials.	Num- ber of analy- ses.	Salt.	Water.	Nutrients.					Fuel value of 1 pound.
				Total.	Pro- tein.	Fat.	Carbo- hy- drates	Min- eral mat- ters.	
MEATS, ETC.—continued.									
Mutton:			<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>Calories</i>
Shoulder	1	.....	58.6	41.4	18.1	22.4	.....	.9	1,280
Breast.....	1	.....	37.6	62.4	14.2	47.2	.....	1	2,255
Rack.....	1	.....	54.9	45.1	18.4	25.9	.....	.8	1,435
Neck.....	1	.....	55.7	44.3	16.2	27.3	.....	.8	1,455
Leg.....	1	.....	61.8	38.2	18.3	19	.....	.9	1,140
Loin.....	1	.....	49.3	50.7	15	35	.....	.7	1,755
Flank.....	1	.....	38.7	61.3	15.8	45	.....	.5	2,195
Fore quarter.....	.....	.....	55.2	47.8	17	29.9	.....	.9	1,580
Hind quarter.....	.....	.....	54.7	45.3	16.9	27.5	.....	.9	1,475
Side without kidney fat.....	.....	.....	53.5	46.5	16.9	28.7	.....	.9	1,525
Lamb:									
Shoulder	1	.....	51.8	48.2	17.5	29.7	.....	1	1,580
Breast.....	1	.....	56.2	43.8	19.2	23.6	.....	1	1,355
Neck.....	1	.....	56.7	43.3	17.5	24.8	.....	1	1,375
Leg.....	1	.....	64.7	35.3	18.9	15.3	.....	1.1	1,000
Loin.....	1	.....	54.8	45.2	19	25.1	.....	1.1	1,410
Fore quarter.....	.....	.....	55.1	44.9	18.1	25.8	.....	1	1,425
Hind quarter.....	.....	.....	60.9	39.1	18.9	19.1	.....	1.1	1,155
Side without kidney fat.....	.....	.....	57.9	42.1	18.6	22.5	.....	1	1,295
Liver.....	1	.....	52.7	47.3	24.2	13.2	7.9	2	1,155
Heart.....	1	.....	67.4	32.6	18.3	13.4	.....	.9	905
Lungs.....	1	.....	74.6	25.4	21.5	2.6	.....	1.5	510
Pork:									
Shoulder roast..... { Min ..	4	.....	45.8	46.9	14.9	30.4	.....	.9	1,590
{ Max ..	4	.....	53.1	54.2	16.9	37.7	.....	.9	1,880
{ Avg ..	4	.....	50.3	49.7	16	32.8	.....	.9	1,680
Poultry, etc.:									
Chicken.....	1	.....	72.2	27.8	24.4	2	.....	1.4	540
Chicken liver.....	1	.....	69.3	30.7	22.3	4.2	2.4	1.8	635
Chicken heart.....	1	.....	72	28	21.2	5.4	.....	1.4	620
Chicken gizzard.....	1	.....	72.5	27.5	24.7	1.4	.....	1.4	520
Turkey.....	1	.....	66.2	33.8	23.9	8.7	.....	1.2	810
Turkey liver.....	1	.....	69.6	30.4	22.9	5.2	.6	1.7	655
Turkey heart.....	1	.....	68.6	31.4	17.2	13.2	.....	1	875
Turkey gizzard.....	1	.....	62.7	37.3	21.7	14.5	.....	1.1	1,015
Hens' eggs in shell { Min ..	27	.....	72	24.8	13.8	9.1	.....	.7	650
{ Max ..	27	.....	75.3	28	16.1	12.5	.....	1.6	795
{ Avg ..	27	.....	73.8	26.2	14.9	10.5	.....	.8	720
Preserved meats:									
Corned beef, rump.....	1	.....	58.1	41.9	13.3	26.6	.....	2	1,370
Corned beef, flank { Min ..	2	.....	43.2	43.5	12.9	24.9	.....	2.8	1,340
{ Max ..	2	.....	56.5	56.8	15.5	41.1	.....	3.1	1,975
{ Avg ..	2	.....	49.8	50.2	14.2	33	.....	3	1,655
Corned beef, canned { Min ..	2	.....	51.9	46.4	24.5	14.1	.....	3.4	1,130
{ Max ..	2	.....	53.6	48.1	28.9	20.2	.....	3.4	1,310
{ Avg ..	2	.....	52.8	47.2	26.7	17.1	.....	3.4	1,220
Dried beef..... { Min ..	2	.....	58	40.8	27.6	4.2	.2	6.3	740
{ Max ..	2	.....	59.2	42	29.9	4.6	2.7	7.3	755
{ Avg ..	2	.....	58.6	41.4	28.8	4.4	1.4	6.8	745
Tripe, soured.....	1	.....	84	16	13.9	1.8	.....	.3	335
Salt pork, fat.....	1	.....	12.1	87.9	.9	82.8	.....	4.2	3,510
Smoked ham.....	1	.....	41.5	58.5	16.7	39.1	.....	2.7	1,960
Pork sausage..... { Min ..	2	.....	37.8	55.5	13.5	40.1	.....	1.9	1,945
{ Max ..	2	.....	44.5	62.2	14.1	45.5	.....	2.6	2,180
{ Avg ..	2	.....	41.2	58.8	13.8	42.8	.....	2.2	2,065
Bologna sausage.....	1	.....	62.4	37.6	18.8	15.8	.....	3	1,015
FISH, SHELLFISH, ETC.									
Fresh fish:									
Sturgeon.....	1	.....	78.7	21.3	18	1.9	.....	1.4	415
Red horse.....	1	.....	78.6	21.4	17.9	2.3	.....	1.2	430
Herring.....	1	.....	69	31	18.5	11	.....	1.5	810
Alewife..... { Min ..	2	.....	72.7	24.1	18.8	3.8	.....	1.5	510
{ Max ..	2	.....	15.9	27	19.5	6	.....	1.5	615
{ Avg ..	2	.....	74.4	25.6	19.2	4.9	.....	1.5	565
Shad..... { Min ..	7	.....	65.3	26.4	17.8	6.5	.....	.9	630
{ Max ..	7	.....	73.6	34.8	20	13.6	.....	1.5	940
{ Avg ..	7	.....	70.6	29.4	18.6	9.5	.....	1.3	745
Smelt..... { Min ..	2	.....	78.2	19.8	15.9	1.7	.....	1.4	375
{ Max ..	2	.....	80.2	21.8	18.8	1.9	.....	2	420
{ Avg ..	2	.....	79.2	20.8	17.3	1.8	.....	1.7	400
Whitefish.....	1	.....	69.8	30.2	22.1	6.5	.....	1.6	685
Ciscoe.....	1	.....	76.1	23.9	19.1	3.6	.....	1.2	505

TABLE 2.—Composition of food materials, edible portion—Continued.

Food materials.	Num- ber of analy- ses.	Salt.	Water.	Nutrients.					Fuel value of 1 pound.	
				Total.	Pro- tein.	Fat.	Carbo- hy- drates	Min- eral mat- ters.		
FISH, SHELLFISH, ETC.—cont'd.										
Fresh fish—Continued.			<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>Calories</i>	
California salmon	{ Min ..	2	.....	62.7	35.5	17	16.5	.....	1	1,030
	{ Max ..	2	.....	64.5	37.3	18	19.3	.....	1.1	1,130
	{ Avg ..	2	.....	63.6	36.4	17.4	17.9	.....	1.1	1,080
Salmon	{ Min ..	5	.....	61	32.9	19.2	12.5	.....	1.2	885
	{ Max ..	5	.....	67.2	39	24.5	15	.....	1.6	1,010
	{ Avg ..	5	.....	63.6	36.4	21.6	13.4	.....	1.4	965
Lake trout	{ Min ..	2	.....	68.8	30.5	17.3	10.2	.....	1.2	785
	{ Max ..	2	.....	69.5	31.2	19.1	12.6	.....	1.4	855
	{ Avg ..	2	.....	69.1	30.9	18.2	11.4	.....	1.3	820
Brook trout	{ Min ..	3	.....	75.8	20.2	18.5	.8	.....	1	380
	{ Max ..	3	.....	79.8	24.2	20	2.9	.....	1.4	495
	{ Avg ..	3	.....	77.7	22.3	19	2.1	.....	1.2	440
Pickerel	{ Min ..	2	.....	79.5	20.2	18.4	.5	.....	1.1	365
	{ Max ..	2	.....	79.8	20.5	18.9	.5	.....	1.2	375
	{ Avg ..	2	.....	79.7	20.3	18.6	.5	.....	1.2	365
Pickerel, pike		1	.....	79.8	20.2	18.6	.6	.....	1	370
Muscalonge		1	.....	76.3	23.7	19.6	2.5	.....	1.6	470
Eel, salt water	{ Min ..	2	.....	69.8	26.6	17.6	7.9	.....	.9	960
	{ Max ..	2	.....	73.4	30.2	19	10.3	.....	1.1	790
	{ Avg ..	2	.....	71.6	28.4	19.3	9.1	.....	1	725
Mullet		1	.....	74.9	25.1	19.3	4.6	.....	1.2	555
Mackerel	{ Min ..	6	.....	64	21.3	17.5	2.2	.....	1	430
	{ Max ..	6	.....	78.7	36	19.3	16.3	.....	1.5	1,025
	{ Avg ..	6	.....	73.4	26.6	18.2	7.1	.....	1.3	640
Spanish mackerel		1	.....	68.1	31.9	20.6	9.8	.....	1.5	790
Pompano	{ Min ..	2	.....	67.4	21.8	18.2	1.6	.....	1	425
	{ Max ..	2	.....	78.2	32.6	19.2	18.5	.....	1	910
	{ Avg ..	2	.....	72.8	27.2	18.6	7.6	.....	1	665
Bluefish		1	.....	78.5	21.5	19	1.2	.....	1.3	405
Butter-fish		1	.....	70	30	17.8	11	.....	1.2	795
Black bass	{ Min ..	2	.....	74.8	21.4	19.2	1	.....	1.2	400
	{ Max ..	2	.....	78.6	25.2	21.5	2.5	.....	1.2	505
	{ Avg ..	2	.....	76.7	23.3	20.4	1.7	.....	1.2	450
Yellow perch	{ Min ..	2	.....	78.1	19.6	17.9	.6	.....	1.1	360
	{ Max ..	2	.....	80.4	21.9	19.5	1.1	.....	1.3	410
	{ Avg ..	2	.....	79.3	20.7	18.7	.8	.....	1.2	380
Wall eyed pike		1	.....	79.7	20.3	18.4	.5	.....	1.4	365
Gray pike		1	.....	80.8	19.2	17.3	.8	.....	1.1	355
Striped bass	{ Min ..	6	.....	75.8	20.3	16.7	1.6	.....	.9	405
	{ Max ..	6	.....	79.7	24.2	18.8	4.6	.....	1.4	525
	{ Avg ..	6	.....	77.7	22.3	18.3	2.8	.....	1.2	460
White perch	{ Min ..	2	.....	75.6	24.2	17.6	2.5	.....	1.1	485
	{ Max ..	2	.....	75.8	24.4	20.4	5.6	.....	1.3	565
	{ Avg ..	2	.....	75.7	24.3	19	4.1	.....	1.2	525
Sea bass		1	.....	79.3	20.7	18.8	.5	.....	1.4	370
Grouper	{ Min ..	2	.....	79	20	18.5	.5	.....	1.1	365
	{ Max ..	2	.....	80	21	19.2	.7	.....	1.1	385
	{ Avg ..	2	.....	79.4	20.6	18.9	.6	.....	1.1	375
Red snapper	{ Min ..	3	.....	77.3	20.2	18.3	.5	.....	1.3	360
	{ Max ..	3	.....	79.8	22.7	19.9	1.9	.....	1.3	440
	{ Avg ..	3	.....	78.5	21.5	19.2	1	.....	1.3	400
Porgy	{ Min ..	3	.....	72	20.3	17.5	1.5	.....	1.4	390
	{ Max ..	3	.....	79.7	28	19.3	7.9	.....	1.4	685
	{ Avg ..	3	.....	75	25	18.5	5.1	.....	1.4	560
Sheepshead	{ Min ..	2	.....	72	20.9	18.9	.7	.....	1.1	380
	{ Max ..	2	.....	79.1	28	20.2	6.7	.....	1.3	660
	{ Avg ..	2	.....	75.6	24.4	19.5	3.7	.....	1.2	520
Red bass		1	.....	81.6	18.4	16.7	.5	.....	1.2	230
Kingfish		1	.....	79.2	20.8	18.7	.9	.....	1.2	385
Weakfish		1	.....	79	21	17.4	2.4	.....	1.2	425
Blackfish	{ Min ..	4	.....	77	18.6	17.4	.6	.....	.7	350
	{ Max ..	4	.....	81	23	19	2.8	.....	1.4	470
	{ Avg ..	4	.....	79.1	20.9	18.5	1.3	.....	1.1	400
Hake		1	.....	83.1	16.9	15.2	.7	.....	1	310
Cusk		1	.....	82	18	16.9	.2	.....	.9	325
Haddock	{ Min ..	4	.....	80.3	17.4	15.9	.1	.....	1	305
	{ Max ..	4	.....	82.6	19.7	18.4	.4	.....	1.6	350
	{ Avg ..	4	.....	81.7	18.3	16.8	.5	.....	1.2	325
Cod	{ Min ..	5	.....	80.7	16.5	15	.3	.....	1	285
	{ Max ..	5	.....	83.5	19.3	17.6	.5	.....	1.3	340
	{ Avg ..	5	.....	82.6	17.4	15.8	.4	.....	1.2	310
Tomcod		1	.....	81.5	18.5	17.1	.4	.....	1	335
Pollock		1	.....	76	24	21.7	.8	.....	1.5	440
Halibut	{ Min ..	3	.....	70.1	20.8	17.5	2.2	.....	.9	420
	{ Max ..	3	.....	79.2	29.9	19.4	10.6	.....	1.2	785
	{ Avg ..	3	.....	75.4	24.6	18.3	5.2	.....	1.1	560

TABLE 2.—Composition of food materials, edible portion—Continued.

Food materials.	Num- ber of analy- ses.	Salt.	Water.	Nutrients.					Fuel value of 1 pound.	
				Total.	Pro- tein.	Fat.	Carbo- hy- drates.	Min- eral mat- ters.		
FISH, SHELLFISH, ETC.—cont'd.										
Fresh fish—Continued.										
Turbot.....	1	.....	<i>P. ct.</i> 71.4	<i>P. ct.</i> 28.6	<i>P. ct.</i> 12.9	<i>P. ct.</i> 14.4	<i>P. ct.</i>	<i>P. ct.</i> 1.3	<i>Calories</i> 850	
Flounder.....	{ Min..	3	83.4	15	12.9	.4	.....	1.2	275	
	{ Max..	3	85	16.6	14.7	.7	.....	1.3	300	
	{ Avg..	3	84.2	15.8	13.9	.6	.....	1.3	285	
Lamprey eel.....	1	.....	71.1	28.9	14.9	13.3	.....	.7	840	
Skate.....	1	.....	82.2	17.8	15.3	1.4	.....	1.1	345	
Preserved fish:										
Desiccated cod.....	1	2.9	15.2	81.9	74.6	1.9	.....	5.4	1,470	
Salt cod.....	{ Min..	2	22.7	53.5	23	21.2	.3	1.6	405	
	{ Max..	2	23.4	53.6	23.8	21.7	.4	1.6	420	
	{ Avg..	2	23	53.6	23.4	21.4	.4	1.6	410	
Boned cod.....	1	21.5	54.3	24.2	22.2	.3	.....	1.7	425	
Salt mackerel.....	1	10.6	42.2	47.2	22.1	22.6	.....	2.5	1,365	
Smoked haddock.....	11	.2	72.5	25.4	23.7	.2	.....	1.5	450	
Smoked halibut ...	{ Min..	2	12.9	47.7	35.9	18.2	14.4	2	995	
	{ Max..	2	13.1	51.1	39.4	23	15.6	2.1	1,035	
	{ Avg..	2	12.9	49.4	37.7	20.6	15.1	2	1,020	
Canned mackerel.....	1	1.9	68.2	29.9	19.9	8.7	.....	1.3	735	
Canned salmon.....	{ Min..	3	.4	57.6	33.6	19.2	11.1	1.3	865	
	{ Max..	3	2.2	65.9	42	21.3	21.5	1.4	1,265	
	{ Avg..	3	1	61.9	37.1	20.1	15.7	1.3	1,035	
Canned sardines.....	1	.....	56.4	43.6	25.3	12.7	.....	5.6	1,005	
Canned tunny.....	1	.....	72.7	27.3	21.5	4.1	.....	1.7	575	
Canned salt mack- erel.	{ Min..	2	9.4	43.2	45.2	16.9	24.8	2.5	1,375	
	{ Max..	2	11.2	43.6	47.3	17.7	27.9	2.7	1,490	
	{ Avg..	2	10.3	43.4	46.3	17.3	26.3	2.6	1,430	
Canned smoked haddock...	1	5.6	68.7	25.7	21.8	2.3	.....	1.6	505	
Shellfish, etc.:										
Oysters in shell....	{ Min..	34	.....	81.7	8.6	4.2	.6	1.8	135	
	{ Max..	34	.....	91.4	18.3	8.5	1.7	6.7	345	
	{ Avg..	34	.....	87.1	12.9	6.1	1.2	3.6	230	
Oysters, "solids"...	{ Min..	4	.....	85.2	11.6	5.9	1.5	3.2	230	
	{ Max..	4	.....	88.4	14.8	6.6	1.8	5.6	300	
	{ Avg..	4	.....	87.2	12.8	6.3	1.6	.9	260	
Canned oysters ...	{ Min..	3	.....	84.6	14	7	2	4.1	285	
	{ Max..	3	.....	86	15.4	8	2.2	5.2	310	
	{ Avg..	3	.....	85.3	14.7	7.4	2.1	3.9	300	
Long clams from shell.	{ Min..	4	.....	85	13.9	8.1	1	1.5	225	
	{ Max..	4	.....	86.1	15	9	1.2	2.5	255	
	{ Avg..	4	.....	85.8	14.2	8.6	1	2	240	
Long clams, canned.....	1	.....	84.5	15.5	9	1.3	2.9	2.3	275	
Round clams from shell....	1	.....	86.2	13.8	6.5	.4	4.2	2.7	215	
Round clams, canned.....	1	.....	83	17	10.4	.8	3	2.8	285	
Scallops.....	{ Min..	2	.....	77.8	17.2	14.4	.....	1.1	310	
	{ Max..	2	.....	82.8	22.2	15.1	.3	5.7	385	
	{ Avg..	2	.....	80.3	19.7	14.7	.2	3.4	345	
Mussels from shell.....	1	.....	84.2	15.8	8.7	1.1	4.1	1.9	285	
Lobster from shell.	{ Min..	4		79.2	15.7	12.3	1.5		1.6	310
	{ Max..	4		84.3	20.8	17.8	2.5		1.9	395
	{ Avg..	4		81.8	18.2	14.6	1.9		1.7	350
Lobster, canned ...	{ Min..	2		76.2	20.6	17.4	.5		2.2	340
	{ Max..	2		79.4	23.8	20	1.7		2.8	445
	{ Avg..	2		77.7	22.3	18.7	1.1		2.5	395
Crayfish.....	1	.....	81.2	18.8	17	.5	.....	1.3	335	
Crab.....	1	.....	77.1	22.9	17.8	2	.....	3.1	415	
Crabs, canned.....	{ Min..	2		79	19	16.5	.8		1.8	340
	{ Max..	2		81	21	16.7	2.3		2.1	410
	{ Avg..	2		80	20	16.5	1.5		2	370
Shrimp.....	1	.....	70.8	29.2	25.6	1	.....	2.6	520	
Terrapin.....	1	.....	74.5	25.5	21	3.5	.....	1	540	
Green turtle.....	1	.....	79.8	20.2	18.5	.5	.....	1.2	365	
DAIRY PRODUCTS, ETC.										
Milk.....	.....	.....	87	13	3.6	4	4.7	.7	325	
Butter.....	.....	.....	10.5	89.5	1	85	.5	3	3,615	
Cheese, full cream.....	{ Min..	5	27	63.2	26	30	.8	3.7	1,815	
	{ Max..	5	36.8	73	30.6	38.3	3.5	4.8	2,185	
	{ Avg..	5	30.2	69.8	28.3	35.5	1.8	4.2	2,070	
Cheese, skim-milk.....	1	.....	41.3	58.7	38.4	6.8	8.9	4.6	1,165	
Oleomargarine.....	.....	.....	11	89	.6	85	.4	3	3,605	

TABLE 2.—Composition of food materials, edible portion—Continued.

Food materials.	Num- ber of analy- ses.	Salt.	Water.	Nutrients.					Fuel value of 1 pound.
				Total.	Pro- tein.	Fat.	Carbo- hy- drates.	Min- eral mat- ters.	
VEGETABLE FOODS.									
			<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>Calories</i>
Potatoes ¹	{ Min ..	12	75.4	17.8	1.1	.....	14.3	.8	315
	{ Max ..	12	82.2	24.6	3	.1	21.2	1.2	445
	{ Avg ..	12	78.9	21.1	2.1	.1	17.9	1	375
Sweet potatoes ¹	{ Min ..	6	66	25.6	.5	.3	18.6	.7	465
	{ Max ..	6	74.4	34	3.6	.6	32.2	1.3	620
	{ Avg ..	6	71.1	28.9	1.5	.4	26	1	530
Red beets ¹	{ Min ..	9	85.5	7.8	1.1	.1	4.5	.7	130
	{ Max ..	9	92.2	14.5	1.8	.3	13	1.6	250
	{ Avg ..	9	88.5	11.5	1.5	.1	8.8	1.1	195
Turnips ¹	{ Min ..	7	87.1	7.6	.8	.1	5	.7	135
	{ Max ..	7	92.4	12.9	1.4	.3	10.5	1.4	225
	{ Avg ..	7	89.4	10.6	1.2	.2	8.2	1	185
Carrots ¹	{ Min ..	8	86.5	8.9	.8	.2	6	.6	155
	{ Max ..	8	91.1	13.5	2	.7	12.7	1.3	235
	{ Avg ..	8	88.6	11.4	1.1	.4	8.9	1	205
Onions ¹	{ Min ..	6	81.5	6.5	.8	.2	4.2	.4	120
	{ Max ..	6	93.5	18.5	2.3	.4	15.5	.7	335
	{ Avg ..	6	87.6	12.4	1.4	.3	10.1	.6	225
Squash, flesh ¹	{ Min ..	3	85.3	10.3	.7	.....	8.1	.5	190
	{ Max ..	3	89.7	14.7	1.1	.3	13.2	.9	265
	{ Avg ..	3	88.1	11.9	.9	.2	10.1	.7	215
Pumpkin, flesh ¹	{ Min ..	2	92.4	5.6	.9	.1	3.9	.6	95
	{ Max ..	2	94.4	7.6	1	.1	5.9	.7	130
	{ Avg ..	2	93.4	6.6	.9	.1	4.9	.7	110
Cucumber ¹	{ Min ..	2	95.7	3.7	.8	.2	2.3	.5	65
	{ Max ..	2	96.3	4.3	.8	.2	2.8	.5	75
	{ Avg ..	2	96	4	.8	.2	2.5	.5	70
Cabbage, entire	{ Min ..	2	87.5	6.4	2.1	.2	3.4	.7	110
	{ Max ..	2	93.6	12.5	2.7	.5	7.2	2.1	205
	{ Avg ..	2	90.5	9.5	2.4	.4	5.3	1.4	155
Cabbage, inner leaves ¹	{ Min ..	2	91.9	5.7	1.5	.2	3.4	.6	100
	{ Max ..	2	94.3	8.1	1.5	.2	5.7	.6	140
	{ Avg ..	2	93.1	6.9	1.5	.2	4.6	.6	120
Cauliflower	1	.....	90.8	9.2	1.6	.8	5	.8	155
Lettuce	{ Min ..	3	91.5	5.4	1.4	.4	2.4	.9	90
	{ Max ..	3	94.6	8.5	1.8	.6	4.9	1.2	150
	{ Avg ..	3	93.1	6.9	1.6	.5	3.7	1.1	120
Spinach	1	.....	92.4	7.6	2.1	.5	3.1	1.9	120
Rhubarb, stems	1	.....	92.7	7.3	.8	1.2	4.4	.9	145
Asparagus	{ Min ..	3	93.6	5.8	1.6	.2	3.1	.5	105
	{ Max ..	3	94.2	6.4	2.1	.3	3.5	1	110
	{ Avg ..	3	94	6	1.8	.2	3.3	.7	105
Tomatoes	{ Min ..	6	95.5	3.7	.7	.3	2.2	.3	75
	{ Max ..	6	96.3	4.5	.9	.5	2.8	.4	80
	{ Avg ..	6	96	4	.8	.4	2.5	.3	80
Green peas	1	.....	78.1	21.9	4.4	.5	16.1	.9	400
String beans	{ Min ..	2	83.5	9	1.7	.3	6.3	.7	160
	{ Max ..	2	91	16.5	2.8	.4	12.6	.8	305
	{ Avg ..	2	87.2	12.8	2.2	.4	9.5	.7	235
Lima beans, green	1	.....	68.5	31.5	7.1	.7	22	1.7	570
Okra	1	.....	87.4	12.6	2	.4	9.5	.7	230
Green sweet corn	1	.....	81.2	18.8	2.8	1.1	14.2	.7	360
Eggplant	1	.....	92.9	7.1	1.2	.3	5.1	.5	130
Peas	1	.....	83.9	16.1	.6	.8	14.2	.5	290
Peas, canned	{ Min ..	82	77.5	7.3	1.6	.1	6.1	.3	130
	{ Max ..	82	92.7	22.5	6.1	.4	15.1	2	405
	{ Avg ..	82	85.4	14.6	3.6	.2	9.7	1.1	255
Haricots verts, canned	{ Min ..	6	94.3	3.9	.9	.....	2	.9	55
	{ Max ..	6	96.1	5.7	1.4	.3	3.1	1.3	95
	{ Avg ..	6	95.1	4.5	1.1	.1	2.6	1.1	70
String beans, canned	{ Min ..	18	90.7	3.7	.6	.....	2	.5	60
	{ Max ..	18	96.3	9.3	1.5	.1	5.9	2.3	140
	{ Avg ..	18	94.3	5.7	.9	.1	3.5	1.2	85
Stringless beans, canned	{ Min ..	7	92.4	5.6	.1	.1	2.8	.9	65
	{ Max ..	7	94.4	7.6	1.3	.1	4.8	1.8	115
	{ Avg ..	7	93.9	6.1	1.1	.1	3.5	1.4	90
Haricots flageolets, canned	{ Min ..	3	80.4	16.1	4	.....	10.8	.9	275
	{ Max ..	3	83.9	19.6	5.2	.1	13.5	1.7	335
	{ Avg ..	3	81.6	18.4	4.6	.1	12.5	1.2	320

¹ These, as ordinarily found in the market, have more or less refuse. The figures for composition for all of them except "cabbage, entire," as for the other vegetable food materials apply to the edible portion. Observations made in connection with studies of dietaries here have led to the use of the following figures as representing the percentages of refuse: Onions, 10 per cent; sweet potatoes, 12.5 per cent; potatoes, 15 per cent; cabbage, 15.5 per cent; turnips, 30 per cent; squash, 50 per cent; apples and grapes, each 25 per cent.

TABLE 2.—Composition of food materials, edible portion—Continued.

Food materials.	Num- ber of analy- ses.	Salt.	Water.	Nutrients.					Fuel value of 1 pound.
				Total.	Pro- tein.	Fat.	Carbo- hy- drates.	Min- eral mat- ters.	
VEGETABLE FOODS—continued.									
			<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>Calories</i>
Haricots panaches, canned	1	.....	86.1	13.9	3.7	.....	9.2	1	240
Little green beans, canned	1	.....	93.8	6.2	1.2	.1	3.4	1.5	90
Wax beans, canned	1	.....	94.7	5.3	1	.1	3	1.2	80
Lima beans, canned.....	Min ..	15	75.7	16.1	3.2	.2	10.5	1	275
	Max ..	15	83.9	24.3	5.7	.6	17.9	2.6	445
	Avg ..	15	79.7	20.3	4	.3	14.4	1.6	355
Baked beans, canned....	Min ..	12	64.3	30.6	6.4	1.3	19.1	1.7	595
	Max ..	12	69.4	35.7	7.7	5.5	21.2	2.6	745
	Avg ..	12	67.2	32.8	7.1	3.2	20.3	2.2	645
Red kidney beans, canned	1	.....	72.7	27.3	7	.2	18.5	1.6	485
Corn, canned.....	Min ..	43	68.3	16.3	2	.7	13	.5	310
	Max ..	43	83.7	31.7	3.4	1.9	25.8	1.5	615
	Avg ..	43	75.4	24.6	2.8	1.3	19.6	.9	470
Artichokes, canned.....	Min ..	3	90.2	6.1	.5	.....	3.7	1.4	90
	Max ..	3	93.9	9.8	1	.....	6.8	2.2	140
	Avg ..	3	92.5	7.5	.8	.....	5	1.7	110
Sweet potato.....	1	.....	68.4	31.6	1.3	.3	29.2	.8	580
Okra, canned.....	Min ..	4	94	5.1	.5	.....	3.3	.3	75
	Max ..	4	94.9	6	.9	.2	3.7	1.7	95
	Avg ..	4	94.4	5.6	.7	.1	3.6	1.2	85
Brussels sprouts, canned	1	.....	93.8	6.2	1.5	1	3.4	1.3	95
Tomatoes, canned.....	Min ..	11	92.5	5.1	1.1	.1	3.5	.5	90
	Max ..	11	94.9	7.5	1.6	.3	5.1	1.2	135
	Avg ..	11	93.7	6.3	1.3	.2	4.2	.6	110
Asparagus, canned....	Min ..	14	92.9	4.6	.9	.....	2.1	.8	70
	Max ..	14	95.4	7.1	2.4	.2	4.1	1.8	115
	Avg ..	14	94.4	5.6	1.5	.1	2.8	1.2	85
Pumpkin, canned.....	Min ..	5	89.4	5.7	.5	.1	4.7	.4	100
	Max ..	5	94.3	10.6	.9	.4	8.8	.6	195
	Avg ..	5	92.7	7.3	.7	.1	6	.5	139
Squash, canned.....	Min ..	2	85.6	12.5	.2	.1	10.6	.2	230
	Max ..	2	87.5	14.4	.9	.5	13.9	.6	265
	Avg ..	2	86.6	13.4	.5	.3	12.2	.4	250
Macedoine, canned.....	Min ..	5	91.5	4.1	.6	.....	2.3	.8	56
	Max ..	5	95.9	8.5	1.7	.....	5.7	1.2	140
	Avg ..	5	93.1	6.9	1.3	.....	4.6	1	110
Succotash, canned.....	Min ..	10	71.4	20.1	2.9	.7	15	.7	375
	Max ..	10	79.9	28.6	4.1	1.1	22.4	1.5	530
	Avg ..	10	76.2	23.8	3.5	.9	18.5	.9	445
Mixed corn and toma- toes, canned.....	Min ..	2	83.6	8.5	1.2	.3	6.4	.5	155
	Max ..	2	91.5	16.4	2.1	.4	12.7	1.2	285
	Avg ..	2	87.5	12.5	1.7	.4	9.5	.9	225
Mixed okra and toma- toes, canned.....	Min ..	3	91.4	7.7	1.1	.2	5.1	1.4	125
	Max ..	3	92.3	8.3	1.2	.3	5.7	1.8	140
	Avg ..	3	91.8	8.2	1.2	.2	5.2	1.6	130
Apples flesh.....	Min ..	2	82.2	15.9	.2	.3	15.1	.2	300
	Max ..	2	84.1	17.8	.3	.5	16.7	.3	335
	Avg ..	2	83.2	16.8	.3	.4	15.9	.2	320
Cherries, flesh.....	1	.....	86.1	13.9	1.1	.8	11.4	.6	265
Strawberries	Min ..	19	87.7	6	.6	.4	4.4	.4	120
	Max ..	19	94	12.3	1.2	1.1	8.3	.8	235
	Avg ..	19	90.8	9.2	1	.7	6.9	.6	175
Blackberries	1	.....	88.9	11.1	.9	2.1	7.5	.6	245
Whortleberries	1	.....	82.4	17.6	.7	3	13.5	.4	390
Cranberries	1	.....	87.6	12.4	.4	.9	10.9	.2	350
Grapes, Catawba	1	.....	74.8	25.2	1.6	1.7	21.3	.6	500
Lemons.....	Min ..	2	88.4	9.8	.8	.2	8.2	.5	175
	Max ..	2	90.2	11.6	1.1	1.6	8.5	.5	245
	Avg ..	2	89.3	10.7	1	.9	8.3	.5	210
Banana, pulp.....	1	.....	66.3	33.7	1.4	1.4	29.8	1.1	640
Pineapple	1	.....	89.3	10.7	.4	.3	9.7	.3	200
Watermelon, flesh or pulp	1	.....	91.9	8.1	.9	.7	6.2	.3	160
Nutmeg melon, flesh or pulp	1	.....	76.4	23.6	1.4	.2	20.5	1.5	415
Rice	Min ..	10	11.4	86	.9	.3	77.6	.3	1,600
	Max ..	10	14	88.6	8.6	.6	81	.5	1,655
	Avg ..	10	12.4	87.6	7.4	.4	79.4	.4	1,630
Beans, dried	Min ..	3	10.4	85	20.4	1.4	57.2	2.7	1,560
	Max ..	3	15	89.6	26.6	3.1	60.4	3.7	1,685
	Avg ..	3	12.6	87.4	23.1	2	59.2	3.1	1,615
Maize meal	Min ..	77	8	72.6	7.1	2	60.9	.9	1,405
	Max ..	77	27.4	92	13.9	5.1	77.1	4.1	1,805
	Avg ..	77	15	85	9.2	3.8	70.6	1.4	1,645
White hominy.....	Min ..	2	13.4	86.4	8.1	.4	77.4	.4	1,610
	Max ..	2	13.6	86.6	8.4	.5	77.5	.5	1,620
	Avg ..	2	13.5	86.5	8.3	.4	77.4	.4	1,620

TABLE 2.—Composition of food materials, edible portion—Continued.

Food materials.	Num-ber of analy-ses.	Salt.	Water.	Nutrients.					Fuel value of 1 pound.
				Total.	Pro-tein.	Fat.	Carbo-hy-drates.	Min-eral mat-ters.	
VEGETABLE FOODS—continued.									
			<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>Calories</i>
Oatmeal	{ Min ..	6	6.2	91.2	12.9	6.1	67.3	1.8	1,820
	{ Max ..	6	8.8	93.8	16.3	8.8	70.1	2.2	1,875
	{ Avg ..	6	7.8	92.2	14.7	7.1	68.4	2	1,845
Pearl barley		1	11.8	88.2	8.4	.7	78.1	1	1,635
Rye flour	{ Min ..	4	12.4	86.4	.6	.8	77.9	.6	1,615
	{ Max ..	4	13.6	87.6	7.1	.9	79.5	.8	1,625
	{ Avg ..	4	13.1	86.9	6.7	.8	78.7	.7	1,625
Wheat flour	{ Min ..	22	8.2	85.7	8.6	.6	71.6	.3	1,625
	{ Max ..	22	14.3	91.8	13.6	1.8	79.5	.7	1,680
	{ Avg ..	22	12.5	87.5	11	1.1	74.9	.5	1,645
Graham flour	{ Min ..	3	12.1	86.3	11.3	1.5	71.6	1.7	1,610
	{ Max ..	3	13.7	87.9	12.4	1.9	72	2	1,645
	{ Avg ..	3	13.1	86.9	11.7	1.7	71.7	1.8	1,625
Entire wheat flour	{ Min ..	2	12.9	86.9	13.1	1.9	69.5	1.4	1,615
	{ Max ..	2	13.1	87.1	14.1	2	70.5	1.4	1,660
	{ Avg ..	2	13	87	13.6	2	70	1.4	1,640
Cracked wheat	{ Min ..	2	9.8	88.9	11.9	1.5	73.9	1.4	1,660
	{ Max ..	2	11.1	90.2	12	1.8	75.2	1.4	1,700
	{ Avg ..	2	10.4	89.6	11.9	1.7	74.6	1.4	1,680
Buckwheat flour	{ Min ..	4	12.8	82.4	4.2	.7	71.6	.7	1,560
	{ Max ..	4	17.6	87.2	8.1	1.8	79.6	1.3	1,640
	{ Avg ..	4	14.6	85.4	6.9	1.4	76.1	1	1,605
Buckwheat farina		1	11.2	88.8	3.3	.3	84.8	.4	1,650
Buckwheat groats		1	10.6	89.4	4.8	.6	83.4	.6	1,665
Wheat bread	{ Min ..	5	31.2	66.5	8.6	.6	55.2	.6	1,245
	{ Max ..	5	33.5	68.8	9.2	2.5	58.5	1.2	1,300
	{ Avg ..	5	32.3	67.7	8.8	1.7	56.3	.9	1,280
Graham bread		1	34.2	65.8	9.5	1.4	53.3	1.6	1,225
Rye bread		1	30	70	8.4	.5	59.7	1.4	1,285
Boston crackers		1	8.3	91.7	10.7	9.9	68.7	2.4	1,895
Soda crackers		1	8	92	10.3	9.4	70.5	1.8	1,900
Pilot (bread) crackers		1	7.9	92.1	12.4	4.4	74.2	1.1	1,795
Oyster crackers		1	3.9	96.1	11.3	4.8	77.5	2.5	1,855
Oatmeal crackers		1	4.9	95.1	10.4	13.7	69.6	1.4	2,065
Graham crackers		1	5	95	9.8	13.6	69.7	1.9	2,050
Starch		2	2	98			97.8	.2	1,820
Sugar, granulated			2	98			97.8	.2	1,820
Molasses			24.6	75.4			73.1	2.3	1,360

TABLE 3.—Composition of water-free substance of edible portion of side of beef of medium fatness.

Portion taken for analysis.	Nitrogen.	Protein (N. × 6.25).	Fat.	Ash.	Protein, fat, and ash.	Protein by dif-ference.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
First cut neck	7.64	47.75	51.19	2.42	101.36	46.39
Second cut neck	9.09	56.83	40.80	3.02	100.65	56.18
Third cut neck	8.19	51.19	45.49	2.69	99.37	51.82
First cut chuck ribs	5.99	37.44	61.34	2.09	100.87	36.57
Second cut chuck ribs	7.46	46.63	48.48	2.79	97.90	48.73
Third cut chuck ribs	8.37	52.31	45.90	3.02	101.23	51.08
First cut ribs	4.58	28.63	69	1.64	99.27	29.36
Second cut ribs	4.63	28.94	69.85	1.67	100.46	28.48
Third cut ribs	4.82	30.13	68.86	1.70	100.69	29.44
Brisket	4.16	26	70.69	1.54	98.23	27.77
Shoulder clod	9.94	62.13	34.55	3.56	100.24	61.89
Cross ribs	3.94	24.63	74.13	1.36	100.12	24.51
Shin	13.99	87.46	8.78	4.76	101	86.46
Plate	4.35	27.19	70.85	1.44	99.48	27.71
Navel	4.75	29.69	69.52	1.58	100.79	28.90
Small end sirloin	6.72	42	54.80	2.22	99.02	42.98
Hip sirloin	6.68	41.76	55.76	2.29	99.81	41.95
Socket	6.29	39.32	58.76	2.37	100.45	38.87
Rump	4.02	25.13	74.18	1.31	100.62	24.51
First cut round	9.20	57.50	39.48	3.17	100.15	57.35
Second cut round	10.87	67.94	28.16	4.36	100.46	67.48
Leg	11.99	74.94	20.33	4.31	99.58	75.36
Top of sirloin	3.80	23.75	75.57	1.31	100.63	23.12
Flank	2.75	17.19	82.55	.90	100.64	16.55
Kidney fat	.17	1.06	98.88	.20	100.14	.92

TABLE 4.—*Composition of flesh (edible portion) of side of beef of medium fatness.*

Portion taken for analysis.	Water.	Water-free substance.	Protein by difference.	Fat.	Ash.	Protein (N. $\times$ 6.25).	Water, protein, fat, and ash.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
First cut neck	60.64	39.36	18.26	20.15	0.95	18.79	100.53
Second cut neck	64.48	35.52	19.96	14.49	1.07	20.18	100.22
Third cut neck	61	39	20.21	17.74	1.05	19.96	99.75
Total neck	61.99	38.01	19.25	17.74	1.02	.....	.....
First cut chuck ribs	53.11	46.89	17.15	28.76	.98	17.56	100.41
Second cut chuck ribs	58.21	41.79	20.38	20.25	1.16	19.50	99.12
Third cut chuck ribs	63.67	36.33	18.57	16.67	1.09	18.95	100.38
Total chuck ribs	58.06	41.94	19.06	21.78	1.10	.....	.....
First cut ribs	46.21	53.79	15.82	37.09	.88	15.38	99.56
Second cut ribs	48.64	51.36	14.63	35.87	.86	14.86	100.23
Third cut ribs	48.48	51.52	15.16	35.48	.88	15.52	100.36
Total ribs	47.82	52.18	15.22	36.08	.88	.....	.....
Brisket	47.41	52.59	14.58	37.20	.81	13.68	99.10
Shoulder clod	66.61	33.39	20.66	11.54	1.19	20.74	100.08
Cross ribs	43.95	56.05	13.73	41.56	.76	13.80	100.07
Shin	73.80	26.20	22.66	2.30	1.24	22.90	100.24
Plate	44.36	55.64	15.41	39.43	.80	15.13	99.72
Navel	47.59	52.41	15.14	36.44	.83	15.56	100.42
Total fore quarter	54.12	45.88	17.27	27.65	.96	.....	.....
Small end sirloin	60.68	39.32	16.92	21.53	.87	16.50	99.58
Hip sirloin	58.86	41.14	17.26	22.94	.94	17.18	99.92
Small end and hip sirloin	59.86	40.14	17.07	22.17	.90	.....	.....
Socket	57.12	42.88	16.67	25.19	1.02	16.86	100.19
Rump	40.23	59.77	14.65	44.34	.78	15.02	100.37
First cut round	66.04	33.96	19.48	13.40	1.08	19.53	100.05
Second cut round	69.53	30.47	20.57	8.57	1.33	20.71	100.14
First cut and second cut round	66.76	33.24	19.71	12.40	1.13	.....	.....
Leg	72.15	27.85	20.99	5.66	1.20	20.87	99.88
Top of sirloin	42.20	57.80	13.36	43.68	.76	13.75	100.39
Flank	27.45	72.55	12.01	59.89	.65	12.47	100.46
Total hind quarter, except kidney fat	55.66	44.34	17.11	26.27	.96	.....	.....
Kidney fat	4.30	95.70	.89	94.62	.19	1.02	100.13
Whole side	52.43	47.57	16.44	30.20	.93	.....	.....
Wholeside, except kidney fat	54.77	45.23	17.20	27.07	.96	.....	.....

TABLE 5.—*Composition of side of beef of medium fatness as received, including both edible portion and refuse.*

Portion taken for analysis.	Refuse.	Edible portion.	Edible portion.				
			Water.	Water-free substance.	Nutrients.		
					Protein by difference.	Fat.	Ash.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
First cut neck	18.37	81.63	49.50	32.13	14.90	16.45	0.78
Second cut neck.....	18.74	81.26	52.40	28.86	16.22	11.77	.87
Third cut neck.....	22.86	77.14	47.06	30.08	15.59	13.68	.81
Total neck	19.54	80.46	49.88	30.58	15.49	14.27	.82
First cut chuck ribs.....	19.45	80.55	42.78	37.77	13.82	23.16	.79
Second cut chuck ribs	19.59	80.41	46.81	33.60	16.39	16.28	.93
Third cut chuck ribs.....	16.31	83.69	53.29	30.40	15.54	13.95	.91
Total chuck ribs	18.80	81.20	47.14	34.06	15.48	17.69	.89
First cut ribs	21.36	78.64	36.34	42.30	12.44	29.17	.69
Second cut ribs	22.70	77.30	37.60	39.70	11.31	27.73	.66
Third cut ribs.....	20.35	79.65	38.61	41.04	12.07	28.26	.71
Total ribs.....	21.34	78.66	37.62	41.04	11.97	28.38	.69
Brisket	14.33	85.67	40.62	45.05	12.49	31.87	.69
Shoulder clod	15.62	84.38	56.21	28.17	17.43	9.74	1
Cross ribs.....	12.17	87.83	38.60	49.23	12.06	36.50	.67
Shin	40.16	59.84	44.16	15.68	13.56	1.38	.74
Plate.....	17.90	82.10	36.42	45.68	12.65	32.13	.66
Navel.....	11.41	88.59	42.16	46.43	13.41	32.28	.74
Total fore quarter	18.45	81.55	44.13	37.42	14.09	22.55	.78
Small end sirloin	24.46	75.54	45.84	29.70	12.78	16.26	.66
Hip sirloin.....	27.32	72.68	42.78	29.90	12.54	16.68	.68
Small end and hip sirloin	25.79	74.21	44.42	29.79	12.67	16.45	.67
Socket	35.79	64.21	36.68	27.53	10.70	16.17	.66
Rump.....	16.18	83.82	33.72	50.10	12.28	37.17	.65
First cut round	7.74	92.26	60.93	31.33	17.97	12.36	1
Second cut round	32.12	67.88	47.20	20.68	13.96	5.82	.90
First cut and second cut round	14.13	85.87	57.33	28.54	16.92	10.65	.97
Leg	62.22	37.78	27.26	10.52	7.93	2.14	.45
Top of sirloin	3.23	96.77	40.84	55.93	12.93	42.27	.73
Flank.....	11.47	88.53	24.30	64.23	10.63	53.02	.58
Total hind quarter, except kidney fat.....	20.23	79.77	44.40	35.37	13.65	20.96	.76
Kidney fat	-----	100	4.39	95.70	.89	94.62	.19
Whole side.....	18.48	81.52	42.74	38.78	13.40	24.62	.76
Wholeside, except kidney fat.....	19.21	80.79	44.25	36.54	13.90	21.87	.77

TABLE 6.—*Composition of side of beef of medium fatness (weights of ingredients in meat as received).*

Portion taken for analysis.	In whole specimen, as taken for analysis.						
	Total weight of cut.	Refuse.	Edible portion.	Edible portion.			
				Water.	Protein by difference.	Fat.	Ash.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
First cut neck.....	8.09	1.48	6.61	4.01	1.21	1.33	0.06
Second cut neck.....	6.05	1.13	4.92	3.18	.98	.71	.05
Third cut neck.....	4.33	.99	3.34	2.04	.67	.59	.04
Total neck.....	18.47	3.60	14.87	9.23	2.86	2.63	.15
First cut chuck ribs.....	11.75	2.28	9.47	5.03	1.63	2.72	.09
Second cut chuck ribs.....	20.60	4.04	16.56	9.64	3.38	3.35	.19
Third cut chuck ribs.....	9.44	1.54	7.90	5.03	1.47	1.32	.08
Total chuck ribs.....	41.79	7.86	33.93	19.70	6.48	7.39	.36
First cut ribs.....	7.23	1.54	5.69	2.63	.90	2.11	.05
Second cut ribs.....	6.82	1.55	5.27	2.56	.77	1.89	.05
Third cut ribs.....	9.41	1.91	7.50	3.63	1.14	2.66	.07
Total ribs.....	23.46	5	18.46	8.82	2.81	6.66	.17
Brisket.....	13.64	1.96	11.68	5.54	1.70	4.35	.09
Shoulder clod.....	17.15	2.68	14.47	9.64	2.99	1.67	.17
Cross ribs.....	14.76	1.80	12.96	5.69	1.78	5.39	.10
Shin.....	11.11	4.46	6.65	4.91	1.51	.15	.08
Plate.....	15.37	2.75	12.62	5.60	1.94	4.98	.10
Navel.....	19.51	2.23	17.28	8.22	2.62	6.30	.14
Total fore quarter.....	175.26	32.34	142.92	77.35	24.69	39.52	1.36
Small end sirloin.....	13.44	3.29	10.15	6.16	1.72	2.18	.09
Hip sirloin.....	11.74	3.21	8.53	5.02	1.47	1.96	.08
Small end and hip sirloin.....	25.18	6.50	18.68	11.18	3.19	4.14	.17
Socket.....	9.66	3.46	6.20	3.55	1.03	1.56	.06
Rump.....	12.61	2.04	10.57	4.25	1.55	4.69	.08
First cut round.....	37.52	2.90	34.62	22.87	6.74	4.64	.37
Second cut round.....	13.33	4.28	9.05	6.29	1.86	.78	.12
First cut and second cut round.....	50.85	7.18	43.67	29.16	8.60	5.42	.49
Leg.....	8.58	5.24	3.24	2.34	.68	.18	.04
Top of sirloin.....	10.24	.33	9.91	4.18	1.33	4.33	.07
Flank.....	13.18	1.51	11.67	3.21	1.40	6.99	.07
Total hind quarter, except kidney fat.....	130.30	26.36	103.94	57.87	17.78	27.31	.98
Kidney fat.....	12	.....	12	.52	.11	11.35	.02
Whole side.....	317.56	58.70	258.86	135.74	42.58	78.18	2.36
Whole side, except kidney fat.....	305.56	58.70	246.86	135.22	42.47	66.83	2.34

TABLE 7.—*Composition of water-free substance of edible portion of side of mutton and side of lamb.*

Portion taken for analysis.	Nitrogen.	Protein (N. × 6.25).	Fat.	Ash.	Protein, fat, and ash.	Protein by difference.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Side of mutton:						
Shoulder.....	6.97	43.56	54.09	2.28	99.93	43.63
Breast.....	3.51	21.94	75.60	1.62	99.16	22.78
Neck.....	5.75	35.94	61.76	1.79	99.49	36.45
Rack.....	6.47	40.44	57.50	1.72	99.66	40.78
Leg.....	7.59	47.43	49.69	2.36	99.48	47.95
Loin.....	4.69	29.31	69.01	1.43	99.75	29.56
Flank.....	4.07	25.44	73.48	.75	99.67	25.77
Kidney and kidney fat.....	1.21	7.56	94.20	.50	102.26	5.30
Side of lamb:						
Shoulder.....	6	37.50	61.54	2.12	101.16	36.34
Breast.....	6.96	43.50	53.91	2.31	99.72	43.78
Neck.....	6.53	40.81	57.28	2.27	100.36	40.45
Leg.....	8.95	55.94	43.38	3.04	102.36	53.58
Loin.....	6.89	43.06	55.60	2.34	101	42.06

TABLE 8.—*Composition of flesh (edible portion) of side of mutton and of side of lamb.*

Portion taken for analysis.	Water.	Water-free substance.	Protein by difference.	Fat.	Ash.	Protein (N. $\times$ 6.25).	Water, protein, fat, and ash.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Side of mutton:							
Shoulder	58.56	41.44	18.08	22.41	0.95	18.05	99.97
Breast	37.60	62.40	14.22	47.17	1.01	13.69	99.47
Neck	55.69	44.31	16.16	27.36	.79	15.93	99.77
Rack	54.94	45.06	18.38	25.91	.77	18.22	99.84
Fore quarter	52.22	47.78	16.96	29.88	.94	-----	-----
Leg	61.80	38.20	18.32	18.98	.90	18.12	99.80
Loin	49.27	50.73	14.99	35.01	.73	14.87	99.88
Flank	38.73	61.27	15.78	45.03	.46	15.59	99.81
Hind quarter	54.67	45.33	16.92	27.53	.88	-----	-----
Kidney and kidney fat....	18.81	81.19	4.30	76.48	.41	6.14	101.84
Side of lamb:							
Shoulder	51.83	48.17	17.51	29.64	1.02	18.06	100.55
Breast	56.24	43.76	19.16	23.59	1.01	19.04	99.88
Neck	56.69	43.31	17.54	24.81	.96	17.67	100.13
Fore quarter	55.06	44.94	18.12	25.82	1	-----	-----
Leg	64.72	35.28	18.91	15.30	1.07	19.74	100.83
Loin	54.82	45.18	19	25.12	1.06	19.45	100.45
Hind quarter	60.88	39.12	18.96	19.09	1.07	-----	-----
Whole side, except kidney and kidney fat.....	57.94	42.06	18.53	22.50	1.03	-----	-----

TABLE 9.—*Composition of side of mutton and side of lamb as received, including both edible portion and refuse.*

Portion taken for analysis.	Refuse.	Edible portion.	Edible portion.				
			Water.	Water-free substance.	Nutrients.		
					Protein by difference.	Fat.	Ash.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Side of mutton:							
Shoulder	16.29	83.71	49.02	34.69	15.14	18.76	0.79
Breast	14.95	85.05	31.98	53.07	12.09	40.12	.86
Neck	27.58	72.42	40.33	32.09	11.70	19.82	.57
Rack	19.28	80.72	44.35	36.37	14.84	20.91	.62
Fore quarter	18.97	81.03	42.31	38.72	13.74	24.22	.76
Leg	18.12	81.88	50.60	31.28	15	15.54	.74
Loin	15.75	84.25	41.51	42.74	12.63	29.50	.61
Flank	2.15	97.85	37.90	59.95	15.44	44.06	.45
Hind quarter	15.65	84.35	46.11	38.24	14.27	23.23	.74
Kidney and kidney fat....	-----	100	18.81	81.19	4.30	76.48	.41
Whole side, except kidney fat.....	17.30	82.70	44.23	38.47	14.01	23.71	.75
Side of lamb:							
Shoulder	20.33	79.67	41.29	38.38	13.96	23.61	.81
Breast	19.09	80.91	45.50	35.41	15.50	19.09	.82
Neck	17.67	82.33	46.67	35.66	14.44	20.43	.79
Fore quarter	18.84	81.16	44.69	36.47	14.71	20.95	.81
Leg	17.70	82.30	53.26	29.04	15.56	12.60	.88
Loin	12.18	87.82	48.14	39.68	16.69	22.06	.93
Hind quarter	15.65	84.35	51.35	33	15.99	16.11	.90
Whole side, except kidney fat.....	17.30	82.70	47.92	34.78	15.32	18.61	.85

TABLE 10.—*Composition of side of mutton and side of lamb (weights of ingredients in materials as received).*

Portion taken for analysis.	Total weight of cut.	Refuse.	Edible portion.	Edible portion.			
				Water.	Nutrients.		
					Protein by difference.	Fat.	Ash.
Side of mutton:	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Shoulder	3.17	0.52	2.65	1.55	0.48	0.59	.03
Breast	1.98	.29	1.69	.63	.24	.80	.02
Neck	1.73	.48	1.25	.69	.20	.35	.01
Rack	2.29	.45	1.84	1.01	.34	.48	.01
Fore quarter	9.17	1.74	7.43	3.88	1.26	2.22	.07
Leg	5.20	.94	4.26	2.62	.79	.81	.04
Loin	3.26	.51	2.75	1.36	.41	.96	.02
Flank	.93	.02	.91	.35	.14	.41	.01
Hind quarter	9.39	1.47	7.92	4.33	1.34	2.18	.07
Kidney and kidney fat	.39	.....	.39	.07	.02	.30	.....
Whole side	18.95	3.21	15.74	8.28	2.62	4.70	.14
Whole side, except kidney fat	18.56	3.21	15.35	8.21	2.60	4.40	.14
Side of lamb:							
Shoulder	2.85	.57	2.28	1.18	.40	.68	.02
Breast	3.57	.68	2.89	1.63	.55	.68	.03
Neck	3.03	.53	2.50	1.42	.44	.62	.02
Fore quarter	9.45	1.78	7.67	4.23	1.39	1.98	.07
Leg	5.50	.97	4.53	2.93	.86	.69	.05
Loin	3.32	.41	2.91	1.60	.55	.73	.03
Hind quarter	8.82	1.38	7.44	4.53	1.41	1.42	.08
Whole side, except kidney fat	18.27	3.16	15.11	8.76	2.80	3.40	.15

WORK NOW NEEDED IN ANALYSIS OF FOODS.

In the present condition of our knowledge of the composition of materials used for the food of man and with the results which have accumulated up to the present, investigation is especially needed in two directions: (1) The study of the methods of analysis with a view to their improvement, and (2) analyses of a sufficient number of specimens to give a clear idea of the range in composition and the average proportions of ingredients in the materials in common use in the United States. The study of methods is one of the pressing necessities of physiological chemistry at the present time. So many analyses of food materials have been made by the current methods that it is hardly desirable to devote a very large amount of labor to further analyses except for specific purposes, such as the study of dietaries, i. e., the actual food consumption of people in different places and under different conditions of life, and the study of the food supply of particular places and of the composition of certain classes of food materials of which but few analyses have thus far been made. If the studies of dietaries should be carried out in different parts of the country in the manner and to the extent which now seem to be desirable the analyses involved will bring the larger part of the information that is most needed regarding the composition of our ordinary food materials.

IMPROVEMENT OF METHODS OF ANALYSIS.

Among the things of fundamental importance for furthering the knowledge of the value and proper uses of foods is the improvement of methods of analysis. This necessity will be clearer if we consider

what are the things we have to analyze and exactly why we analyze them. We have to distinguish here between the materials which are used as the food of man and those which are fed to domestic animals. The former may be conveniently designated as food materials or foods and the latter as fodder materials or feeding stuffs.

The methods of analysis used for foods are similar to those for feeding stuffs, and the two classes of materials need to be studied together.

Classification of ingredients.—We make analyses of foods and feeding stuffs to learn their value for nutriment and the proper ways to use them. In doing so we classify the ingredients in different groups, as stated on pages 11 and 12, and assign to each group a specific nutritive value.

Present usage makes the groups practically the same for all vegetable substances, thus ignoring the wide differences of kindred compounds in different plants and parts of plants. We even go so far as to make nearly the same grouping for animal as for vegetable compounds. Not only do we thus place compounds of widely different chemical and physiological characters in the same group, but we frequently put into a group compounds which do not belong there at all.

In our analyses we attempt to separate the ingredients and determine their respective amounts. We base our methods of analysis mainly upon two classes of properties, the elementary composition of the compounds, and their solubilities; and yet our knowledge of these properties is imperfect at best, and in some cases scarcely suffices for more than to assure us of the incorrectness of our methods of estimation. In many instances, especially with vegetable materials, the solubility of the compounds in laboratory reagents, their digestibility in laboratory tests by the so-called method of artificial digestion, their actual digestibility in the body of the animal, and their nutritive effect are dependent upon the ways in which they are held in the vegetable tissues, e. g., the nature of the cell walls or incrusting substances. Of these things ordinary chemical analysis tells little or nothing, and we must look to the vegetable histologist for information about them. Meanwhile, in ignorance of them we commit more or less serious error.

In vegetable materials by our present method we determine, or assume that we determine, one group, which we call protein, by multiplying the total nitrogen by 6.25. In many cases we know this factor is wrong, in many others we have no proof at all that it is right. We assume to determine a second group, which we call fats or crude fats, by extracting with ether. We know that, especially in vegetable feeding stuffs, the ether extracts a good deal of material which can not be properly classed with the fats and that it may leave more or less of the true fats unextracted. We estimate what we call fiber or crude fiber by extracting with dilute acid and alkali, and do not know the constitution of the residue, although we are certain that it varies with the conditions of extraction, and that it may contain more or less of other materials than cellulose and lignin. We determine what we call ash by inciner-

ation, and take the residue as representing the mineral matters, although the method does not tell us their forms of combination and the result does not even represent their exact amount. Even the current methods of determining water are extremely faulty. We keep the substance for a certain time at a temperature near that of boiling water, either in air or in a current of hydrogen, and reckon the loss of weight as water. We do not know how much water remains in what we call the water-free residue, but it is certain that in many cases more or less of the organic matter is volatilized and sometimes the quantity which thus escapes is very considerable. And when we have made these rough estimates of water, protein, fat, crude fiber, and ash, we add them together, subtract their sum from the whole weight, and call the difference "non-nitrogenous extract" or "carbohydrates." When this is done we make more or less rough estimates of the digestibility of the several classes of nutrients by use of digestion coefficients of doubtful accuracy. And finally, having thus estimated the total and digestible nutrients, we apply certain figures for estimated heats of combustion of protein, fats, and carbohydrates, and thus calculate the fuel values of our foods and feeding stuffs. Notwithstanding all these difficulties and sources of error it is probable that the results for animal foods are not very far from the truth. With many vegetable foods the case is no worse. Perhaps it is safe to say that the present methods of analyses of animal and vegetable foods are accurate enough to give tolerably fair estimates of their nutritive values, but they are very far from what they should be. The demand for investigation which shall lead to improvement is immediate and pressing.

With vegetable feeding stuffs the case is much worse, so bad indeed that some of the leading experimenters in the United States are inclined to make but little use of chemical analyses in feeding experiments. In my judgment this is going too far, decidedly so. But nevertheless the fact obtains that in estimates of the nutritive values of feeding stuffs, the results of our feeding trials and the teachings of experience are often at variance, and it is not easy to see why. We shall not make them harmonize until we learn how to make our analyses more correct. If the need of improvement of the methods of analysis of food is great the need of improving the methods for feeding stuffs is still greater.

At the same time there is much to encourage us. If we are still using the so-called "Weende methods" of thirty years ago with comparatively little modification we have found out how to get results that are pretty nearly uniform. To this latter consummation the work of such organizations as the Association of Official Agricultural Chemists in the United States and the Association of Experiment Stations in Germany have materially contributed; and it is no disparagement of the great value of that work to say that it is not of exactly the kind that is needed to bring the best results.

The general plan of the cooperative experiments made by these associations is that of testing certain prescribed methods of analysis. The

method of analysis to be followed may be either one in common use or a new one which is to be tested. The details of the operation are minutely described and the substance or substances in which the determinations are to be made are definitely agreed upon. A single sample of a substance of a given class is selected by one analyst and distributed to the others, or each analyst selects the substance for himself. The analyses are made, reported, and compared. Generally little or no effort is made to determine the actual constituents of the compounds that are being dealt with or the conditions of combination and separation which so materially affect the accuracy of the analysis. The work is apt to be mainly a comparison of methods of manipulation in the hands of different men. This is valuable, indeed indispensable, but it does not go to the root of the matter. It is empirical and not truly scientific. It does not reveal the real sources of error and the ways of avoiding them. It is working systematically but not philosophically. It is an attempt to find a path by groping in the dark, where light is needed to show the obstacles, the pitfalls, and the safest and nearest route.

Sources of error and the investigations needed to develop correct methods.—The time has come when systematic effort ought to be made to improve our current methods of analysis. To decide what are the first steps we shall do well to consider the especial difficulties. To do this satisfactorily would require a treatise of considerable length. The present purpose will be served by very brief recapitulation of some of the main points.

Water.—It is becoming evident to experienced analysts that the accurate determination of water is one of the most difficult in this branch of analysis. Just what are the sources of error we do not fully know. We are not certain, for instance with respect to any ordinary material, just how long heating, either at a temperature of 95° , which is common in an ordinary drying oven, or at the exact temperature of boiling water which we sometimes attempt to maintain, or at the higher temperature of 105° or 110° which is occasionally recommended, is necessary for complete expulsion of the water. But we do know that at either of these temperatures there is more or less danger of volatilization of organic substances. Pure filter paper is gradually decomposed and finally charred at temperatures much below 100° . The volatile fatty matters may escape at even lower temperatures. Nitrogenous compounds are likewise driven off under the same circumstances. Some fatty matters absorb oxygen and increase in weight when dried in air; hence the necessity of drying in hydrogen. Not knowing what better to do, we have recourse to the entirely empirical method of drying a given weight of a given substance for a given time at a given temperature, and assuming that if the water is not entirely expelled enough organic matter will be driven off to compensate for the error. But it is clear that in so doing we are not getting accurate results.

Nitrogenous substances.—The method of multiplying the total nitrogen by 6.25 and taking the product as a measure of the nitrogenous substances is a most unsatisfactory makeshift. It does not tell the total quantity of nitrogenous substances, still less does it tell the amount in any given form of combination. Conventionally we call the product protein. We assume it to include in animal foods:

(1) The albuminoids; namely, native albumins, derived albumins, including casein, globulins, coagulated proteids, albumoses, and peptones.

(2) The so-called "gelatinoids," namely, those which make the basis of connective tissue, and derivatives from them. The most important of these are the ones which yield gelatin and chondrin, though the substances which yield elastin and mucin are generally classed with them.

(3) Cleavage products of albuminoids and gelatinoids other than proteoses and peptones. The most important of these for our present purpose are the so-called non-nitrogenous extractives, the group to which kreatin and kreatinin belong.

In the flesh of vertebrates, at least of those most commonly used for food, the total nitrogen multiplied by 6.25 is found to very nearly equal the total nitrogenous substances; in other words, the nitrogen factor 6.25 is a fairly accurate one. But the albuminoids, gelatinoids, and extractives have different functions in nutrition. It is especially important to devise means for accurately separating the extractives.

Considerable work on the methods of analysis of muscular tissue has been performed in the writer's laboratory, the larger part by Dr. H. B. Gibson. We have thus far found no easy and accurate way for separating the nitrogenous extractives, nor have we been able to make an at all satisfactory separation of the albuminoids and gelatinoids by the use of either hot water or dilute (one-fifth per cent) hydrochloric acid. The method which is commonly recommended for separating the gelatin by boiling water proves to be unreliable. In the muscular tissue of beef, from which the fat had been removed as completely as was convenient, and in the flesh of codfish nitrogenous material was dissolved as long as the treatment with hot water was continued, and it was evident that under the treatment some kind of decomposition was constantly going on. This was not surprising in view of the decompositions which take place in the treating of pure albuminous matter, such as blood fibrin, by very dilute acids or alkalis with heat. It accords with the observations that various albuminoids may be changed to substances allied to if not identical with peptones by such treatment. The experience with the dilute hydrochloric acid, which is supposed to dissolve the albuminoids and leave the gelatin-like compounds undissolved, was equally unsatisfactory.

A further result of the investigation just referred to, which still awaits publication, is worth noting here. Muscular tissue of beef and

of codfish was partially dried by heat in air in the way commonly followed in preparing substances for further analysis. This heating in air was continued until the substance was dry and hard enough to be pulverized. The total quantity of nitrogen in the fresh substance and that in the same substance after drying were determined by the Kjeldahl method. It was found that from 1 to 3 per cent of the nitrogen was lost in the process of partial drying. The operation was repeated in a current of hydrogen, which, after passing over the substance, was conducted through hot sulphuric acid. In this way the nitrogen of the volatilized material was approximately determined. In some of the cases with meat it reached 2 per cent, and in some white fleshed fish $2\frac{1}{2}$ per cent of the total nitrogen in the substance. The nitrogen thus volatilized, added to the quantity in partially dried material from which it had escaped, was found in some cases to be almost exactly equal to that in the original substance. Whether the volatilized nitrogenous compounds were nitrogenous extractives or other and more volatile cleavage products was not determined. We suspect that they might have belonged to the latter class, one reason being that the fish was hardly as fresh as the meat and that the flesh of fish is known to yield volatile amines as decomposition products.

This experience has an important bearing upon the determination of nitrogen in animal substances. It is evident that if we partially dry the substance before making the determination of nitrogen we run the risk of loss of nitrogenous material; and yet this is exactly what is done in the ordinary method of analysis. It also has an important bearing upon the determination of water. Ordinarily we estimate the loss of water in the partial drying and then take a smaller portion of the partially dry substance; heat it further until it ceases to lose weight, and call the total loss water. If the water is all expelled and as much volatile organic matter escapes with it, as the observation just mentioned would imply, the water determinations must be wrong.

The studies just referred to imply that there may be a loss of nitrogen in the complete drying which follows the partial drying in the ordinary routine of analysis of animal tissues. This would affect the final result in the same ways as the loss in partial drying.

The nitrogenous substances in vegetable foods include: (1) Albuminoids of various kinds; (2) so-called amides, i. e., synthesis and cleavage products of various kinds.

The vegetable albuminoids appear to be more variable in composition than the animal albuminoids, and the nitrogen factor for them needs to be fitted to the compounds as they actually occur in different classes of food materials. Such investigations as those of Osborne and Chittenden¹ upon this subject are valuable; indeed inquiry of this kind is of fundamental importance.

¹Connecticut State Experiment Station Reports, *passim*; Am. Chem. Jour., vols. 13, 14, 15, *passim*; Jour. Am. Chem. Soc., XVI, 703.

So-called "amids" occur to only a small extent in most of our vegetable foods. In potatoes, however, the quantity is very large and their further study is more to be desired. In feeding stuffs, especially the grasses and forage plants, which are ordinarily harvested during the period of growth and marked cellular activity, the proportions are often large.

The method of Stutzer for the separating of so-called "albuminoids" and "non-albuminoids" of vegetable substances is frequently used and is regarded by some as measurably satisfactory. In the writer's laboratory the experience has not been as favorable as is to be desired, and there is little risk in saying that further investigation of the subject is much needed.

The practice of determining nitrogenous substances by multiplying the total nitrogen by 6.25 is at best a temporary makeshift. In meats, fish, milk, and the cereal grains it is probably not far out of the way, but in all of these, and especially in the meats and fish, it is of the greatest importance to distinguish between the albuminoid nitrogen and that which exists in other forms. The same is true to equal if not greater degree in potatoes and other roots, in ordinary vegetables, and in many feeding stuffs.

Terminology.—One matter that demands attention is the terminology of the nitrogenous substances. This is in almost hopeless confusion. American, English, French, German, and other chemists disagree widely and most curiously in their usage. By a large number the term albuminoid is used in the sense in which it is used here. But it is employed by others not only for other allied compounds, but even for such substances as hæmoglobin. The word "proteids" also meets promiscuous handling by different authorities. * Some make it synonymous with albuminoids; with others it includes what are here called "albuminoids" and "gelatinoids;" by others it is applied to a different and greater variety of nitrogenous materials. And while the term is applied by most physiological chemists, so far as I know, to specific compounds, it is occasionally used by writers on the subject for the total nitrogenous substances in food materials without regard to their composition.

It is, of course, desirable that a nomenclature for the nitrogenous compounds be agreed upon. Provisionally it seems to the writer wise to conform to what is coming to be a very common usage with respect to one term, "protein;" namely, to apply this to the total nitrogenous substance (exclusive of nitrogenous fats) whether obtained by multiplying the nitrogen by 6.25, which is now commonly accepted as the measure of the nitrogenous substance, or by difference as is done with the animal tissues which contain very little carbohydrates.

Fats—Ether extract.—The case with the so-called "crude fat" is no better than with the nitrogenous compounds. In such animal substances as muscular or connective tissue, and milk and its products,

when they are fresh, i. e., when the cleavage of proteids which comes with exposure and the action of bacteria has not proceeded too far, the ether extract, if obtained by proper manipulation, contains probably all the so-called "neutral" fats or "triglycerids" (i. e., the normal propenyl compounds with the fatty and oleic acids), and little else.

The amounts of lecithins in these tissues are very small and very probably their extraction by ether may be complete enough for practical purposes.

In eggs the extraction of lecithin with ether alone is hardly feasible by the ordinary method, indeed, the experience in the writer's laboratory has shown it to be extremely slow and difficult with ether or alcohol, or even with a mixture of ether and alcohol, although I do not feel competent to say that it can not be done easily and quickly by proper manipulation. This is one of the minor details of method that need further investigation.

The compounds commonly extracted from vegetable products and denominated "crude fat," "ether extract," or simply "fats," are very diverse; nor are we at all sure what proportion of them we extract by our ordinary methods. We have to deal not only with the true fats, i. e., glycerids of the fatty acids and the fatty acids themselves, which may be properly classed with the fats in estimating nutritive values, but also with a great variety of other compounds of widely differing constitution, and of whose functions and value in nutrition but little is known. Among them are substituted glycerids, including lecithins, waxes, alkaloids, cholesterin, hydrocarbons, and chlorophylls. Of these, the lecithins appear to have a special value in nutrition, while some of the alkaloids are poisons. An especial and serious difficulty is found with the fats which become insoluble in ether when heated in air. These seem to be abundant in some seeds and grasses. We assume that they are of the nature of the drying oils, like linolein, and take up oxygen on exposure to air. We therefore dry the substance in a current of hydrogen before extracting with ether. This is very essential. The writer has found the quantity of material dissolved by ether from seeds, e. g., of maize, to be reduced three-fourths by drying in air. We have not found this difficulty to occur in animal tissues, and probably the general experience is to the same effect. Unfortunately there is still much doubt as to just what are the bodies which become insoluble in ether by drying in air or the list of materials in which they occur. It is doubtless wise to use hydrogen, especially in the analyses of vegetable materials and to make sure that the hydrogen is free from oxygen. The use of illuminating gas instead of hydrogen for this purpose, which has been found satisfactory in some laboratories,¹ is worthy of more consideration.

¹ See Foerster, Landw. Vers. Stat., 37, 1890, 57 and Experiment Station Record, 5, p. 383; and Märcker, Bieler and Schneidewind, Die agrikultur-chemische Versuchstation Halle a/S., p. 11.

If the substance to be analyzed is finely ground, free from water, and in otherwise normal condition, and the cell structure allows easy extraction we may in general expect that ether, applied in accordance with the official method, which is commonly followed by our stations, will take out the whole of the true fats and fatty acids, and more or less of the lecithins, wax, chlorophyll, cholesterin, alkaloids, and hydrocarbons, and that more or less of the compounds other than true fats and fatty acids will remain undissolved. If the ether contains alcohol the extract may be expected to contain more of the other compounds. If water is present the extract may be larger, as has actually been found to be the case in numerous observations. In other words, the extract, as obtained by the ordinary method, contains either part or all of the fats and fatty acids, as the case may be, and with them more or less of other substances.

With animal foods, except eggs and such materials as the edible portion of oysters in which different organs are included, it is doubtless safe to say that the ordinary method of ether extraction is reasonably satisfactory.

With vegetable foods the case is complicated by the presence of other compounds than the true fats (normal propenyl compounds) and by the fats that become insoluble in drying. But with the cereal products and potatoes, which make up the bulk of our vegetable foods, the ordinary method appears to do very well.

The worst difficulty is with feeding stuffs. In these we have a great variety of other substances than the true fats, and considerable amounts of the fat which oxidize in air, and furthermore we have to do with the incrusting substances which materially hinder extraction. The ether extract is apt to be mixed with materials that do not belong with the fats and to contain only part of the true fat.

There is only one way to remedy this difficulty. It is to find what the substances are which vary so greatly in solubility, in what materials, and under what conditions they occur, and how to classify, separate, and determine them.

The nutritive values of the materials which are more properly grouped as fats, i. e., the glycerids of the fatty acids, and the fatty acids themselves, are pretty well understood, though further investigation of the molecular constitution of some, and of the fuel value of all, is needed. According to the present outlook it seems probable that, although the waxes and perhaps the lecithins may be classed with the fats in estimations of the nutritive values, a separate classification of some or all of the others will be necessary; and it is clear that a more definite knowledge of the chemical constitution of all the materials, other than the neutral fats and fatty acids, is indispensable to any correct estimate of their values for nutriment.

Crude fiber—Cellulose.—The term "crude fiber," like protein, is practically a conventional expression for bridging over the present igno-

rance of the actual substances to which it applies, and the conventional method for its determination is another of the provisional makeshifts of the analytical laboratory.

In the analysis of food this is of minor consequence; the vegetable foods have but little cellulose and less of the incrusting substances which are associated with it, while animal foods have none. In many feeding stuffs the cellulose and ligneous substances which we lump together as crude fiber are a disturbing factor, and a very serious one, in the analysis and in the determination of the digestibility and the nutritive value.

Cellulose is a comparatively well-defined chemical compound, or to speak more accurately, the celluloses found in different plants consist of more or less clearly defined chemical compounds. The celluloses are more or less digestible even by man; they can be converted into sugar, and though their oxidation in the body in such way as to make their potential energy largely available has been called in question, later experimental inquiry ascribes to them, in so far as they are digested, practically the same nutritive value as other carbohydrates.

Intimately associated with cellulose are the ligneous substances. These are as yet but little understood. Such terms as "lignin," "zylogen," "cuticle," and "woody fiber" have been applied to them and to the hardened cell walls or other parts of plant tissue in which they occur. They abound in the more or less completely matured stems of the grasses and cereals and in the outer coatings of seeds. Hence we meet them in hay, straw, cornstalks, bran, and oil cake. They seem to be especially characteristic of what are called coarse fodders. It is these substances, indeed, with others more or less closely allied, which make such fodders indigestible and "coarse."¹ There is extremely little of them in flour and meal of cereal grains, in the seeds of the legumes, tubers, roots, or ordinary fruits. Hence they are not responsible for any large part of the difficulty in the analysis of food materials, but do make a great deal of the trouble we have with feeding stuffs, both in their analysis and in the estimates of feeding value.

Practically what we do in the so-called determination of crude fiber is to treat vegetable substances in an entirely empirical way with dilute acid and alkali, assuming that these remove the nitrogenous substances, and call the undissolved residue crude fiber. How much of cellulose or ligneous compounds may be dissolved we do not know, but we do know very well that more or less nitrogenous and other compounds are often left in the residue thus crudely separated and crudely designated.

¹ See articles on this general subject by Dr. J. B. Lindsey, entitled "The Composition of Wood," in *Agricultural Science*, 1893, Nos. 1-4. These include accounts of investigations by the author and a summary of the late researches upon the celluloses, lignin, and the carbohydrates, and other references to the literature of the subject.

These incrusting substances affect the whole work of analysis of vegetable foods and feeding stuffs.

As regards the bodies which we are wont to classify as "amids," "ether extract," "nitrogen-free extract," and "crude fiber," and which we attempt to estimate by treatment with water, ether, dilute acid and alkali, or other solvents, we are coming to appreciate that their solubility is influenced not only by the fineness of grinding of the sample, the time and temperature of the extraction, the quantity of the water, the purity of the ether, the strength of the acid or alkali, the time and temperature of extraction, and by chemical changes induced in the compounds by fermentation, or by long standing, or by drying in the air, but also by the ways in which they are held within the cells or occur as constituents of the plants.

The observations of the greater digestibility of cellulose in young than in older plants and in plants grown on rich as compared with those grown on poor soil, illustrate this point.

We are beginning to realize that the permeability of the cell walls and other mechanical conditions affect the ease or difficulty of extraction; that the histological structure of the plant is a most important factor; in other words, that here is one of the places where the chemist must have the help of the vegetable physiologist if he will learn to do his work as it ought to be done.

Nonnitrogenous extractives—Carbohydrates.—The use of the term "non-nitrogenous extractives" is another makeshift for covering our ignorance of the compounds we are dealing with and the imperfections of our methods of analysis. The carbohydrates as chemical compounds are coming to be well understood, thanks to the labors of such investigators as Fischer and Kiliani, which are revealing their molecular constitution, and of Tollens and F. Schulze and their associates, who are finding what they are and where they occur. These remarks apply not only to the amyloses, glucoses, and sucroses, but also to the pentoses and the gummy substances from which they are derived, although the nature of the latter is only beginning to be understood. The late progress of research in this direction is most gratifying, not only in the results achieved and promised, but also in the examples it gives of the usefulness of such abstract inquiry. It is a matter of especial congratulation that a number of gentlemen connected with colleges and experiment stations and other institutions in the United States, including Messrs. Allen, De Chalmot, Flint, Lindsey, Stone, and Wheeler, have been engaged in this field of inquiry, and it is much to be hoped that their work may be continued.

The current practice of lumping the known and unknown materials together indiscriminately and simply estimating their total amount, as is done with the nonnitrogenous extractives, is most unsatisfactory. It leaves us in the dark as to the character and nutritive values of the compounds, and is only a rough approximation to their quantity.

With the cereal grains and the flour and meals prepared from them, and with the leguminous seeds commonly used for food, the present state of affairs is not very serious. The error in water determination in drying in hydrogen is probably quite small; the nitrogenous compounds are mostly albuminoids with a nitrogen factor not very far from 6.25, though this factor evidently needs to be fitted to each kind of seed in both the cereals and the legumes; the ether extract may be expected to contain all the true fats, the fatty acids, the bulk of the lecithin, and very little else; the quantity of crude fiber is very small and consists mostly of cellulose; the content of mineral matters is so slight that the error in their determination may be disregarded; the estimate of carbohydrates by difference is thus not very far out of the way; and finally the carbohydrates themselves are reasonably well understood and their heats of combustion are readily determined.

In potatoes the nonnitrogenous extractives consist chiefly of starch, and their estimation by difference may not be very far from correct, provided a way is found for correct determination of the nitrogenous compounds.

Roots, as beets and turnips, and fruits contain large proportions of the bodies to which such names as pectose and pectin are given. Very little is known of the constitution of these compounds. Very likely they may approach the carbohydrates in nutritive value.

It is in the feeding stuffs that the nonnitrogenous extractives are most puzzling. Indeed in the coarse fodders we know extremely little of their nature, and the errors in determining the other ingredients make the estimating of their amounts by difference little better than guesswork.

We have been accustomed to think of the carbohydrates as offering no difficulty in the analyses of animal foods, and are only lately coming to see our mistake. In muscular tissue, e. g., meats and the flesh of fish, they have been entirely ignored; but the late work of Kulz, Pflüger, and others shows that the glycogen content of these substances is much too large to be ignored in accurate investigations of either their composition or their uses in nutrition.

The only carbohydrate supposed to occur to any extent in milk is lactose. Considering that the accurate determination of the water in milk is by no means one of the easy operations of the laboratory, and that any error in this, unless compensated by the slight but very probable errors in determination of protein and fats, will affect the estimate of sugar by difference, it must be allowed that even here the present method is not perfect.

Mineral matters.—That the residue left on incineration and commonly called ash does not exactly represent the mineral matters in the substance analyzed goes without saying. But so long as we are not concerned with the functions of the mineral matters this slight analytical error need not be taken into account.

Summary.—When we summarize the sources of error in our present methods of analysis it is clear that the worst difficulties are those with the feeding stuffs. Nevertheless there is serious need of reform in the methods for analysis of foods.

With animal foods the subjects of which investigation is most pressing needed include—

- (1) Determination of water.
- (2) Separation of nitrogenous extractives from proteids of muscular tissue and determination of both.

- (3) Study of the constitution of the proteids of animal tissues.

- (4) Separation and determination of glycogen in muscular tissue.

In vegetable foods it is especially desirable to investigate—

- (1) The albuminoids.
- (2) The nonalbuminoid nitrogenous compounds, especially in tubers (potatoes).
- (3) The lecithins and other compounds containing nitrogen and phosphorus.

With respect to all these substances the heats of combustion constitute a most important branch of the needed inquiry.

The need of an understanding of the molecular constitution of compounds in order to devise correct methods for learning their digestibility and nutritive values is illustrated by the albuminoids. What is the residue left undissolved by pepsin and trypsin to which the term “nuclein” has been applied? Is there reason for a separate classification of nucleo-albumens? Is there in these or other albuminoids a molecular group containing phosphorus which resists the digestive ferments and is the basis of the undigested portion of the compounds in which it occurs? If so, what is its relation to the nucleus or the nucleolus of the cell? Shall we not have to look to a union of organic chemistry and vegetable physiology for the facts we must have in order to devise plans for correct analyses and determinations of digestibility, potential energy, and nutritive value of the compounds?

The results of future research will doubtless lead not only to changes in the general groupings and methods of analysis, but also to special groupings and methods of analysis for different classes of vegetable and animal foods and feeding stuffs. It is hardly to be expected, for instance, that we shall always hold to the same grouping of compounds for grasses, cereal grains, leguminous plants and their seeds, root crops, milk, and meats. It is more probable that groupings for different classes of materials which shall correspond with methods of analysis and of estimating the nutritive values will prove both necessary and feasible.

It is safe to say that all of the work which has been done in the past and is being done to-day in the analysis of feeding stuffs and the feeding trials based upon them will have to be revised and much of it discarded. A large amount of experimental inquiry is being done which

is not bringing the needed results and can not in the nature of the case be of the highest and most enduring value, and much of it may have to be done over again when correct methods shall have been devised.

The first step toward reform must be research in analytical, organic, physical, and physiological chemistry. The needed improvement of our methods will evidently come only as fast as does the chemical and physiological knowledge which must serve as a basis for changes. This means that the most abstract and profound study is necessary. Fortunately such study is more and more engaging the attention of chemists and vegetable physiologists.

From the chemical standpoint we need: First, such studies as will bring definite knowledge of the kinds and amounts of proximate compounds contained in each substance to be analyzed—that is to say, (1) in different species of plants, as grasses, grains, cereals, legumes, tubers, roots, etc.; (2) in plants of the same species grown under different conditions; (3) in different parts of the same plant, as the stalk and seed of maize and wheat, and the different parts of the wheat grain; (4) in the same plant at different periods of growth; (5) in animal tissues and fluids. For some of the information needed the aid of the histologist must be sought. Second, studies of each compound regarding its behavior with reagents—i. e., solubility, etc.; its elementary composition; its cleavage products; its molecular constitution; the changes it undergoes by the action of ferments; its digestibility, and its potential energy. Third, classifications of the compounds based upon the properties named. Fourth, improved methods for separation and estimation based upon the same properties. Fifth, as the outcome of all this, more correct methods of estimating the nutritive values.

Investigations in these lines have already been undertaken by the Division of Chemistry of the United States Department of Agriculture, by several of the experiment stations, and by other institutions of research. The work of the Association of Official Agricultural Chemists in developing and improving the methods of analysis has been of decided value. It has, however, confined its attention too closely to empirical comparisons of methods of manipulation.

For the collating of the results of previous inquiries, and for the prosecution of the necessary investigations, cooperation of a large number of specialists will, of course, be requisite. We may confidently expect that experiment stations will be able to devote more and more labor to these higher inquiries. The increased resources of our agricultural colleges will enable them to encourage such researches. The scientific value of this work is such that chemists in other colleges and universities ought to be led to join in it. And is it too much to suggest that international cooperation might be secured? The expense of this research may be best met by the wise expenditure of relatively small sums of money judiciously expended, so as to stimulate investigations and bring them to completion. In what the Smithsonian Institution

has done in times past in promoting research by small amounts of money we have an illustration of what might be accomplished here. The result would be useful in several ways. It would encourage research, develop talent, and improve the intellectual tone of the institutions where such work was being done. Its influence upon the development of science in this country would be excellent and the practical value of the outcome would many times exceed the cost.

CHAPTER IV.

THE DIGESTIBILITY OF FOOD.

The value of food for nutriment depends not only upon how much of nutrients it contains, but also upon how much of these the body can digest and use for its support.

The question of the digestibility of foods is very complex, and it is noticeable that the men who know most about the subject are generally the least ready to make definite and sweeping statements concerning it. One of the most celebrated physiologists of the time, an investigator in whose laboratory this particular subject has been studied more than in almost any other, says in his lectures that, aside from the chemistry of the process, and the quantities of nutrients that may be digested from different foods, he is unable to affirm much about it. The contrast between this and the positiveness with which many persons discourse about the digestibility of this or that kind of food, is marked, and has its moral.

One source of confusion is the fact that, what people commonly call the digestibility of food includes several very different things; some of which, as the ease with which a given food material is digested, the time required for the process, the influence of different substances and conditions upon digestion, and the effects upon comfort and health, are so dependent upon individual peculiarities of different persons, and so difficult of measurement, as to make the laying down of hard and fast rules impossible. Why it is, for instance, that some persons are made seriously ill by so wholesome a material as milk, and others find that certain kinds of meat, of vegetables, or of sweetmeats, "do not agree with them," neither chemists nor physiologists can exactly tell. Late investigations, however, suggest the possibility that the ferments in the digestive canal may, with some people, cause particular compounds to be changed into injurious and even poisonous forms, so that it may sometimes be literally true that "one man's meat is another man's poison."¹

But digestion proper, by which we understand the changes which the food undergoes in the digestive canal in order to fit the digestible portion to be taken into the blood and lymph and do its work as nutriment, is essentially a chemical process. About this a great deal has been learned within a comparatively few years, so that here again we have many important facts that have not yet got into current literature.²

¹ See interesting statements upon this subject in Dr. Burdon-Sanderson's "Disorders of Digestion." See also article on "Digestibility of Food" in *Century Magazine*, September, 1887.

² An excellent treatment of the general subject of the chemistry of digestion may be found in Gamgee's *Physiological Chemistry*, Vol. II.

Professor Maly very aptly compares food to ore, and the nutriment digested from it to the metal extracted from ore. In the chemical laboratory a metal is sometimes separated from the earthy matters with which it is mingled by pulverizing the ore, putting it in a flask, pouring acids upon it, and stirring the whole together. The acids dissolve the metal, leaving a residue of earthy matters undissolved. To separate the dissolved materials from the residue, the whole is put upon a filter, through which the solution runs, leaving the undissolved residue in the filter. Something analogous to this takes place in the digestion of food. Instead of the metal and earthy matters of the ore, we have the digestible and the undigestible constituents of meat, or bread, or other material. The grinding is done, not by pestle and mortar, but by the teeth; the digestive juices are the solvents; instead of the flask the dissolving is done in the stomach and intestine. Finally, the digested material has to pass, not through a filter, but through the porous walls of these last organs. The changes which the digestive juices cause are manifold, and not yet fully understood. But the main fact for consideration here is that the undigested residue gives a more or less accurate measuring of the digestibility of the food.

To judge accurately of the nutritive value of food, then, we must know how much of each nutrient will be digested. This is a matter that can be determined more or less accurately by experiment; but a great deal of labor is needed to make the experiments accurate. The line of research is new, the methods are not yet perfectly matured, and the results thus far obtained, though interesting and valuable when taken together, are still very far from complete. The side questions, such as differences in the digestive apparatus of different persons, the effects of exercise and rest, or the mode of preparation of the food, and of the flavoring materials and beverages taken with it, tend to complicate the problem and make satisfactory results still harder to obtain. Yet even here experimental research has brought some definite information.

THE QUANTITIES OF DIGESTIBLE NUTRIENTS IN FOOD.

The question here is, What proportion of each of the nutrients in different food materials is actually digestible? In a piece of meat, for instance, what percentages of the total protein and fats will be digested by a healthy person, and what proportion of each will escape digestion?

The proportions of food constituents digested by domestic animals has been a matter of active investigation in the European agricultural experiment stations during the past thirty years. During the past fifteen years not a little has been done in some stations in the United States. Briefly expressed, the method consists in weighing and analyzing both the food consumed and the intestinal excretion. Since the latter represents nearly the amount of food undigested, if we subtract it from the whole amount taken into the body the difference will be nearly the amount digested.

Such experiments upon human subjects, however, are rendered much more difficult by the fact that in order that the digestibility of each particular food material may be determined with certainty, it must not be mixed with other materials. Hence the diet during the experiments must be so plain and simple as to make it extremely unpalatable. An ox will live contentedly on a diet of hay for an indefinite time, but for an ordinary man to subsist a week on meat or potatoes or eggs is a very different matter. No matter how palatable such a simple food may be, at first, to a man used to the ordinary diet of a well-to-do community, it will almost certainly become repugnant to him in a few days. In consequence, the digestive functions are disturbed, and the accuracy of the trial is impaired, a fact, by the way, which strikingly illustrates the importance of varied diet in civilized life.

For instance, in one of a series of experiments conducted in the physiological laboratory at Munich by Dr. Rubner, the subject, a strong, healthy Bavarian laborer, lived for three days upon bread and water, a diet the monotony of which was much more endurable than one of meat or fish, or almost any other single-food material would have been. He was able to eat 1,185 grams of bread per day. This contained 670 grams of carbohydrates, mainly starch, of which only about 5 grams, or a little less than 1 per cent, escaped digestion. In this case, therefore, about 99 per cent of the carbohydrates of the bread was digested. The bread contained 81 grams of protein, of which 13 per cent was undigested and 87 per cent digested. The quantity of fatty matters in the bread was too small to permit an accurate test of their digestibility.

In another series, conducted by the writer in the same laboratory, the digestibility of meat in the form of beefsteak, and of fish (haddock), was tested. The subject, a medical student, consumed less than 2 pounds of meat per day, and though it was cooked with butter, pepper, salt, and onions, so as to make it to his taste, "extraordinarily well flavored," it was very difficult for him to swallow it the second day, and required still greater effort the third. The digestion, however, seemed to be normal, and all but about 1 per cent of the protein was digested.

Other trials with meat have brought similar results, and it is reasonably safe to say that when a healthy person, with sound digestive organs, eats ordinary meat or fish in proper quantity, all or nearly all of the protein is digested. Some of the fats of meat, however, seem to fail of digestion.

The number of actual experiments of this kind is very small. Nearly all have been published within the past fifteen years. The majority have been made in the physiological laboratory of the University of Munich, of which Voit is the director. Most of the subjects have been men with healthy digestive organs, two or three laboratory servants, a soldier, several medical students, and a few others. Several have been made, however, with children of a few families. All but a very small number have been conducted in Germany.

HISTORICAL SUMMARY.

Observations upon the quantities of nutrients digested from a mixed diet were made by Beneke in 1854; the earliest publication of the results that has come to our notice appeared in 1878.¹ Ranke,² in 1862, published accounts of quantitative tests of the digestibility of meat, but the duration of his experiments was in each case only one day, and the methods of separating the undigested residue from that of the food taken before and after the experiment had not been well elaborated at that time. In 1870 Weiske³ published a careful study of the digestibility of crude fiber by a man with a diet consisting of cabbage, tuberous-rooted celery and carrots. Very little has since been done upon the digestibility of crude fiber by man.

A large amount of valuable work upon the digestibility of different food materials by men was carried out by Rubner⁴ in the Munich physiological laboratory and published between 1879 and 1882. The subjects were a laboratory servant, who was a strong, hearty, rather stolid man of the laboring class, a soldier, and several students and assistants in the laboratory. All, or nearly all, were Bavarians.

Bread, meat, milk, eggs, and numerous other articles of food were studied and full details were published. During the past ten years inquiry in this direction has been somewhat active. Such staples as bread, meat, and milk have naturally received a large share of attention from many investigators. Besides Rubner, who has worked with all three, Prausnitz and Meyer have done much with bread; Ranke, Atwater, and Malfatti have reported results with meat; Atwater with fish; Camerer and Ufflemann with milk; and A. Mayer with butter and oleomargarine. Brief results of some Japanese work have been published but with no details as to method. Among the latest and best investigations in this line are those by Prausnitz in Voit's laboratory, in Munich.

We have found accounts of some 150 digestion experiments which seem accurate enough to be used for statistical inferences. They have been collated in tabular form and from them the selections in Table 11 have been made. Of the total number, 114 have been made with men, 5 with women, and 13 with children from 6 weeks to 14 years of age. Fourteen of the tests were made in Italy, 12 in Holland, and 3 in Japan; the rest were made in Germany. A number were made in connection with studies of dietaries; such were those in Table 11, numbered 39, 40, 41 and 42.

EXPERIMENTAL METHODS.

The real question to be considered in such a study is, What proportions of the several classes of nutrients are actually digested from

¹ Zur Ernährungslehre des gesunden Menschen, 1878, 299.

² König, Chem. d. mensch. Nahr. und Genuss., I, 1889, 37.

³ Ztschr. Biol., 1870, 456.

⁴ Ibid., 1879, 115; 1880, 119.

different food materials by persons under normal conditions as to food consumed, habits, and health? Two methods are commonly used for the study of this question, those of artificial digestion and of actual digestion experiments. The experiments on artificial digestion are made by treating the materials with solutions containing digestive ferments, as pepsin and trypsin. The most valuable work in this line has been done by Stutzer¹ and others. The experiments on actual digestion² are made by letting the subject, man or animal, consume a certain amount of food of known composition and comparing the quantities of water-free substance, protein, "ether extract," ash, etc., of the food and of the undigested residue, the difference being taken as the measure of the amount of the several ingredients digested.

The experiments with artificial digestion are at best only a more or less close imitation of a natural process. The value of this kind of inquiry is beyond question, but much further elaboration of details of reagents and manipulation is needed to make the method satisfactory for accurate measurement of the actual digestibility of food materials by either men or domestic animals.

The only reliable method now available for determining the digestibility of food by man is direct experiment with persons under different and well-defined conditions. Even by the use of this method we are not sure of absolutely accurate results. The chief difficulties are three, (1) the inaccuracy of the present methods of analysis of food and excreta; (2) the difficulty of distinguishing between the metabolic products and the residues of undigested food in the feces, and (3) in case of mixed diet, the impossibility of distinguishing between the undigested residues from the different materials and the effect of one food material upon the digestion of another.

The digestion of different food materials in a mixed diet has received some considerable attention recently from Prausnitz.³ As he points out, there are three possibilities: either (1) each food digests as if it were used alone, or one is (2) hindered or (3) helped in digestion by the presence of the others. The question is a very important one. Another question, and one which demands more attention than it has received, is the effect of the methods of cooking upon the digestibility of food.⁴ Very little accurate experimenting has been done in this especial field.

METHOD OF QUANTITATIVE TEST OF PROPORTIONS OF NUTRIENTS DIGESTED FROM FOOD BY MAN.

The method ordinarily used for testing the quantities of nutrients actually digested is, in substance, the following: The subject and the diet having been determined upon, samples of the food actually eaten

¹Landw. Vers. Stat., 1889, 331; Ztschr. physiol. Chem., IX, 211; XI, 207, 529.

²Ztschr. Biol., 1879, 115, etc.

³Arch. Hyg., 1893, 626.

⁴König, Chem. d. mensch. Nahr. und Genuss., I, 1889, 46.

are analyzed, i. e., the nitrogen, fat, ash, etc., are determined by the usual methods of food analysis. If at the start it is not possible to provide enough of a certain food to last through the experiment, each fresh portion is analyzed.

It is desirable, though not absolutely necessary, that the length of the trial be not less than three days. This has been the length of most of the experiments in the Munich laboratory. The longer the period of the experiment the less will be the error due to imperfect separation of the undigested residue, and the more fully may the effect of the previous food be assumed to be eliminated. On the other hand, if the experiment is continued too long, the monotony of the diet may interfere with the abundant secretion of the digestive juices or otherwise tend to render the results abnormal. The accuracy of tests by this method depends in large part upon the accuracy of the separation of the feces which pertain to the food under investigation from that due to food which precedes and follows it. Two methods of separation are in general use. In one, the subject takes no food but milk during the twenty-four hours, or thereabouts, immediately preceding the actual test. The feces due to milk are whitish in color and of characteristic texture. It is not difficult to mechanically separate this portion from that due to the food which is taken during the test period. This is followed by another day of milk diet, and thus the digested residue of the food of the experimental period is separated from that of the succeeding food. The second plan consists in giving a teaspoonful, or less, of lampblack or powdered charcoal, preferably in gelatin capsules, with the last meal eaten before and the first meal after the period of the experiment. This imparts to the solid excrement a very dark color, and the mechanical separation is comparatively simple. A still more effective way to facilitate accurate separation is to take lampblack with milk before and after the test period. Full details of mechanical manipulations, as improved by later experiments, have been given by Prausnitz.¹

The solid excrement is best collected in weighed dishes of porcelain or metal with smooth surface. It is dried, weighed, and determinations of water, nitrogen, ether extract, and ash are made by the usual methods.

The errors due to the imperfections of the methods of analysis and the presence of other materials than undigested residue will be better appreciated by considering what are the substances to be dealt with. The feces contain (1) the undigested residue of the food and (2) metabolic products.

The undigested residue consists of fragments of muscular fiber, tendon, ligament, elastic fiber, blood vessels, so-called "nucleins" (i. e., undigested proteid material), chlorophylloid matter, vegetable fiber, granules of starch, masses of fat, calcium and magnesium salts of fatty

¹ Ztschr. Biol., 1894, 335.

acids, magnesium ammonium phosphate, and cleavage products of proteids, including skatol and indol.

The metabolic products include epithelium mechanically separated from and mucus secreted by the walls of the alimentary canal, and residues of the digestive secretions. The chief of these latter are those coming from the salivary, pectic and pancreatic glands, and the bile. Pepsin and trypsin furnish considerable nitrogenous matter. The bile furnishes the bile acids and probably coloring matters. Whether cholesterolin, which is normally present, comes from undigested residue or metabolic products or from both is not definitely known.

The quantity of the undigested residue is of course quite considerable, and varies with the conditions, including the quantity of food eaten, and very likely with the time the given diet is followed. For instance, it was found by Berthé¹ that when he consumed 60 grams of cod-liver oil per day the feces of the first day contained 8 grams ether extract, that of the seventh day contained 12 grams, and the quantity increased until on the thirteenth day it was 49 grams. It would seem that in this case the digestive organs gradually lost the power of assimilating large quantities of the materials soluble in ether. Rubner² found that in experiments of three days each, when 233 grams of butter and 145.8 grams of bacon, containing 95.6 per cent of fat, were eaten per day the feces contained 44.6 grams ether extract. When 240 grams of butter were eaten without the bacon only 15.2 grams ether extract was found in the feces, i. e., for large quantities of fat the quantity of ether extract in the solid excrement was proportionally larger than when small quantities were consumed.

The inorganic matter in the ash belongs to both the undigested residue and the metabolic products.

It is evident that where the methods of analysis of feces are the same as those commonly used for food the actual error must be even greater than the results imply. Only a portion of the nitrogen of either undigested residue or metabolic products is in the form of proteids. Much of the rest occurs in cleavage products of the proteids, the nature and amount of which is uncertain. Multiplying the nitrogen by 6.25 is far from giving the actual amount of either proteids or of total nitrogenous substance. The ether extract may contain all the neutral fats and probably more or less of cleavage products, materials from the bile and coloring matter. Ether will not remove these perfectly nor will it alone remove the fatty acids which are in combination with calcium and magnesium. The determinations of crude fiber are very likely as near the truth as in food analysis, but the quantities are small in both in experiments with men except when large amounts of coarse bread or similar food is eaten. Carbohydrates are estimated by difference. Such an estimate must include the combined errors of all the others except in so far as the latter compensate each other.

¹ Hermann's Handbuch der Physiologie, Vol. V, II, p. 243.

² Ztschr. Biol., 1879, 170-180.

The error due to the metabolic products outside of that from imperfect methods of analysis may be very considerable. It falls chiefly upon the protein and fat. The measure of digested nitrogen is the remainder after subtracting the nitrogen in the feces from the total nitrogen in the food. But the subtrahend includes both undigested residue and metabolic products. The latter products represent food material which has been previously digested and metabolized. All the metabolized nitrogen is, therefore, digested nitrogen, and it should be subtracted from the total nitrogen of the feces. The remainder would represent the nitrogen of the undigested residue. This last subtracted from the total in the food would leave the real quantity of nitrogen digested. The figures for the digestibility of nitrogen as ordinarily computed from experiments are really too small by the amount of the metabolic nitrogen in the feces.¹ In Table 12, beyond, the so-called "undigested nitrogen" in the meat, fish, and eggs made from 1.6 to 11.2 per cent of whole. It is customary to assume that this nitrogen belongs to the metabolic products and that the protein is completely digestible. The quantity of ether extract in the feces may be quite considerable because of the presence of bile acids and like products. When the quantity of fat in the foods is very large, as is apt to be the case with meats, the error in results due to the ether extract of the metabolic products may perhaps be neglected; but with vegetable foods in which the total fat is very small the error due to ether extract of metabolic products may seriously impair or entirely vitiate the results. The figures given for undigested fat of vegetable food in the tables beyond can not be taken as reliable.

It is often desirable to know whether the body is gaining or losing nitrogen with the diet used in a digestion experiment. For this purpose the urine is collected and the nitrogen in it is determined.

RESULTS OF EXPERIMENTS UPON QUANTITIES OF NUTRIENTS DIGESTED FROM DIFFERENT FOODS.

With the preceding statements the figures of Tables 11 and 12 will be clear.

Table 11 shows the general character and results of the experiments thus far reported upon the digestibility of food materials by man. It includes the final details of some 35 separate trials and the averages of some of these and other similar ones. The data are selected as fairly representative of the work of this kind reported up to the present time. Table 12 recapitulates experiments upon the digestibility of crude fiber (cellulose) of bread and vegetables by man.

¹See investigations on this subject by Rieder, *Ztschr. Biol.*, 1884, 378.

TABLE 11.—Results of experiments on the digestibility of food materials by men; proportions of nutrients actually digested.

No. of experiment.	Date of experiment.	Food used (quantities per day in grams).	Ingredients of food.						Ingredients of feces.						Food ingredients undigested.				
			Fresh substance.	Water-free substance.	Total nitrogen.	Ether extract.	Carbohydrates.	Ash.	Fresh substance.	Water-free substance.	Total nitrogen.	Ether extract.	Carbohydrates.	Ash.	Water-free substance.	Total nitrogen.	Ether extract.	Carbohydrates.	Ash.
			Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
1	1876	Beef, roasted.....	884	366.8	48.8	20.9	.....	18.6	65.3	17.2	1.2	4.4	.....	2.8	4.7	2.5	21.1	.....	15
2	1876	do.....	738	306.4	39.8	23.9	.....	15.2	53.2	17.1	1.1	4	.....	3.2	5.6	2.8	17.2	.....	21.2
3	1884	Beef, roasted and boiled.....	798	193.7	21.3	48.5	.....	11.8	20	5.4	.4	.9	.....	1	2.8	1.6	1.8	.....	8.2
4	1883	Beef, 1,200 grams; butter, 30 grams.....	1,230	291.2	38.5	61.4	.....	13.3	62.3	13.8	.97	.....	.....	2.9	4.3	2.5	5.2	.....	21.5
5	.....	Average of Nos. 1, 2, 3, and 4.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.4	2.3	11.3	.....	16.5
6	1883	Fish, haddock, 1,584 grams; butter, 30.5 grams.....	1,610.5	296.3	45.6	35.1	.....	18.2	57.8	16	.9	3.2	.....	4.1	4.9	.2	9	.....	22.5
7	1876	Eggs, hard boiled.....	948.1	247.4	20.7	103.3	.....	10.4	.....	11	.6	5.2	.....	1.9	5.2	2.9	.5	.....	18.4
8	1876	Milk.....	2,438	315	15.4	95.1	102.4	17.8	96.3	24.8	1	4.7	.....	8.7	7.8	6.5	3.3	.....	48.8
9	1880	do.....	1,790	224	10.6	53.7	91.3	.....	69	15.9	.6	1.5	.....	.....	7.1	5.4	2.8	.....	.....
10	1889	do.....	3,102.9	350.7	13.3	111.9	319.8	23.4	.....	31.4	1.1	5.7	.....	8.7	9	11.2	5.1	.....	37.1
11	.....	Milk. Average of 7 experiments, including Nos. 8, 9, and 10.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8	7.6	4.5	.....	45.1
12	1877	Milk, 2,291 grams; cheese, 200 grams.....	2,491	419.8	24.1	138.6	96.2	27.5	98.3	25.3	.9	3.8	.....	7.2	6	3.7	2.7	.....	26.1
13	.....	Milk and cheese. Average of 3 experiments, including No. 12.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14	1878	White wheat bread.....	689	421.4	7.6	.....	391.1	9.9	95.2	23.5	2	.....	.....	.....	8	3.8	7.3	.....	37.5
15	.....	White wheat bread. Average of 3 experiments, including No. 14.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.2	25.7	.....	1.4	25.4
16	1869	Rye bread, 816.7 grams; butter, 50 grams.....	816.7	438.1	10.5	.....	.....	18.1	310.1	44.2	2.3	.....	.....	5.5	10.1	22.2	.....	1	24.3
17	.....	Rye bread. Average of 3 experiments including No. 16.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	30.5
18	1892	Wheat and rye bread with yeast.....	1,000	616.3	14.3	.....	.....	21.6	.....	44.5	2.6	.....	.....	7.2	7.2	17.8	.....	.....	33.3
19	1892	Wheat and rye bread leavened.....	1,000	619.1	13.9	.....	.....	18.7	.....	48.3	2.9	.....	.....	6.8	7.9	19.6	.....	.....	36.4
20	1877	Potatoes and butter.....	3,276.5	967.7	11.5	143.8	718.1	64	635	93.8	3.7	5.3	.....	10.1	9.4	32.2	3.7	7.6	15.8

[illegible]

NOTE.—The years are, as nearly as we can find in the literature at our disposal, those in which the experiments were made. Ash average of 5 experiments.

- 1, 2. Rubner, Ztschr. Biol., 1879, 121, 125.
3. Malfatti, König's Chem. d. menschl. Nahr. und Genuss., 1889, Vol. I, p. 37.
- 4, 6. Atwater, Ztschr. Biol., 1888, 16.
- 7, 8. Rubner, Ztschr. Biol., 1879, 128, 130.
9. Camerer, Ztschr. Biol., 1880, 493.
10. Prausnitz, Ztschr. Biol., 1889, 533.
- 12, 14. Rubner, Ztschr. Biol., 1879, 136, 151.
16. Meyer, Ztschr. Biol., 1871, 916.
18. Prausnitz, Ztschr. Biol., 1894, 328.
- 20, 21, 22. Rubner, Ztschr. Biol., 1879, 147, 166, 163.
- 23, 25. Rubner, Ztschr. Biol., 1880, 127, 128.
27. Struppell, König, loc. cit., 46.
28. Prausnitz, Ztschr. Biol., 1890, vol. 26, 227.
- 29, 30, 31. Malfatti, König, 1889, 46.
- 32, 34. Rubner, Ztschr. Biol., 1879, 141, 144.
- 35, 36. Mayer, Landw. Vers. Stat., 1883, vol. 29, 215.
39. Rubner, Ztschr. Biol., 1879, 170.
40. Constantinidi, Ztschr. Biol., 1887, 447.
41. Mori, Ztschr. Biol., 1889, 117.
42. Manfredi, Arch. Hyg., 1893, 576.

TABLE 12.—*Crude fiber (cellulose) digested in experiments with men.*

No. of experiment.	Date of experiment.	Food used, (quantities per day in grams).	Water-free substance in food.	Crude fiber—		
				In food.	In feces.	Undigested.
			Grams.	Grams.	Grams.	Per cent.
40	1886	Potatoes, 1,700 grams; fat, 100 grams; beer, 500 cubic centimeters; gluten, 200 grams .....	.....	5.6	1.2	22
43	1886	Potatoes, 1,700 grams; fat, 100 grams; beer, 500 cubic centimeters .....	.....	4.8	1	21.1
44	1869	Celery, cabbage, carrots, total 1,050 grams	139	12.5	4.7	37.3
45	1869	Celery, cabbage, carrots, total 883.3 grams	117.8	10.4	5.5	52.7
46	1886	Bread, fruit, dry fruit, oil, total 1,802 grams	719	16	9.2	56
47	1886	Bread, fruit, dry fruit, oil, total 1,764.8 grams	692.5	16.7	6.3	37
48	1888	Rice and barley, salted radish, vegetables, total 2,150 grams .....	.....	17.4	4.2	24
41	1888	Rice, salted radish, vegetables, etc., fish, total 1,800 grams	523.8	4.6	.8	17.5
49	1888	Rice, salted radish, vegetables, etc., meat, total 1,500 grams	615.7	6	.5	8.6
18	1892	Wheat and rye bread (with yeast) 1,000 grams	580.1	4.3	2.5	63.1
50	1892	Wheat and rye bread (with yeast), 900 grams	616.3	3.9	2	50.1
19	1892	Wheat and rye bread (leavened), 1,000 grams	554.6	4.7	3.3	70
51	1892	Wheat and rye bread (leavened), 900 grams	619.1	4.3	1.5	36.4
52	1892	Decorticated (entire) rye bread (with yeast), 1,000 grams	557.2	8.2	3.7	45.2
53	1892	Decorticated (entire) rye bread (with yeast), 900 grams	647.3	7.4	4.1	55.9
54	1892	Decorticated (entire) wheat bread (with yeast), 1,000 grams	582.6	6.7	3.7	55.4
55	1892	Rye bread (with yeast), 1,000 grams	640.8	8.2	4.9	59.7
56	1892	Rye bread (with yeast), 900 grams	623	7.6	4.8	63.9
57	1892	Wheat bread (with yeast), 1,000 grams	570	8.9	4.2	47.4
58	1892	Wheat bread (with yeast) 900 grams	640.2	8.1	3.8	46.6
			576.1			

44, 45. Weiske, Ztschr. Biol., 1870, 456.

46, 47. Voit, Ztschr. Biol., 1889, 264, 274.

48, 49. As 41 above. In 49, 200 cubic centimeters of milk were used per day.

50 to 58 (see 18, 19).

NOTES ON TABLES 11 AND 12.

Experiments with beef. Four experiments are here quoted. Nos. 1 and 2 by Rubner, No. 3 by Malfatti, and No. 4 by Atwater. Nos. 1 and 2 were carried out in July and June, 1876, in the laboratory of the Physiological Institute of the University of Munich. The subject was a medical student 22 years old, weighing 72 kilograms. The time of each was 3 days.

In No. 1 the food was lean beef, which was prepared by separating the fat, gristle, and connective tissue as completely as was practicable with shears. The meat thus prepared was fried or roasted with a little butter, onion, salt, and pepper, and eaten either with well water or carbonated water as a beverage. For purposes of analysis specimens of the meat after it had been cooked with the above materials were taken each mealtime and fat and water determined. The quantity of nitrogen in the meat was estimated. For this estimate the nitrogen content of the dry, fat-free flesh was assumed to be 14.11 per cent.¹ The ash was estimated. In the feces the nitrogen was determined by the soda-lime method. Dry matter, fat, and ash were determined by the ordinary methods. The separation of the feces was effected by a milk diet on the day before and the day after the period. No. 2 was made with the same person and by the same methods. Although the meat was extremely palatable, it was almost impossible for the subject to eat it on the third day. Eating meat alone caused a strong aversion to it.

No. 3 is as quoted by König from the original publication.²

Nos. 4 and 6 were made by Atwater for a comparison of the digestibility of meat and fish. The work was done in the Munich Physiological Laboratory in 1883.

¹ As the result of early analyses Voit and his pupils in the Munich Physiological Laboratory assumed for a number of years that lean beef, from which the visible fat and the larger portions of tendon and other connective tissue had been removed as completely as could be done with shears, had an approximately uniform composition.

² "Sitzungsber. Wien. Akad. Wissensch., 1884, III Abth. Dez.-Heft."

The subject was a medical student, some 22 years of age and weighing 70 kilograms. The nitrogen, fat, dry matter, and ash were determined in each case by the usual methods. The meat was purchased in a market in Munich, and the separations of fat and connective tissue were made by the same laboratory servant and in the same way as in other experiments in this laboratory. The fish was haddock brought from the Baltic and sold in Munich. The experiments were made in winter, and the fish was well preserved. The fish was freed from skin, bone, etc., by the method followed by Atwater and assistants in the chemical investigation of fishes.¹ The composition of the flesh agreed very nearly with that of haddock taken off the New England coast. The beef was leaner in appearance and contained considerable less fat than has been found in any one of a number of specimens purchased in Middletown, Conn., and treated in the same way. There is, however, no reason to assume that this difference materially affects the digestion.

No. 7. This experiment was made in 1876 by Rubner, also in Munich. The subject was a student of medicine, 24 years of age, weighing 46 kilograms. The time was 2 days. The only food was eggs, which were boiled hard in the shells and eaten with a little salt. Water was the only beverage used. The dry matter in the eggs was determined, but the nitrogen, fat, and ash were calculated from previous analyses by Voit. Determinations were made of the dry matter, nitrogen, fat, and ash in the feces. Milk was not used to separate the feces, as they were characteristic. It will be seen that practically the same amount of dry substance and nitrogen were digested in the experiment with eggs as in those with meat, while the percentage of digested fat in the eggs was larger. Rubner remarks:

“It is well known that the protein of eggs is coagulated by heating to 100°, while the syntonin and myosin, the chief protein in meat, is not coagulated by heat. It requires however, an acid, or the action of digestive juices, to dissolve it. From the fact that eggs are as completely digested as meat it does not follow that they are digested in the same time or that the hard-boiled eggs do not produce more disturbance in the digestive organs. It is highly probable that soft-boiled eggs are as thoroughly digested as hard boiled.”

No. 8. This experiment was also made by Rubner in Munich in 1876. The subject was a professional man 27 years of age, weighing 71 kilograms. The time was 3 days. The only food used was milk. The dry matter, nitrogen, fat, sugar, and ash in the milk were estimated from previous analyses by Voit. The feces were analyzed, the dry matter, nitrogen, ether extract, and ash being determined. “No carbohydrates or protein were found.” The milk feces could, of course, be easily separated.

Rubner remarks that the solid matter of milk is not as completely digested by adults as that of meat or eggs. This is largely due to the fact that the percentage of ash in the solid matter is larger in milk than in the other two. According to Rubner the undigested organic matter from meat amounted to 4.1 to 4.7 per cent, from eggs 4.7 per cent, and from milk 5.4 per cent of the whole—not a very considerable difference. Young children digest milk more completely than adults. Forster² found that only 6.4 per cent of the solid matter of milk was undigested by a nursing infant. This may, perhaps, be explained by the fact that a considerable part of the ash of milk is composed of calcium salts, and these would be more needed by the young organism for the formation of bones than would be the case with an adult, and not so much would be left in the undigested residue to form insoluble salts of the fatty acids.

No. 9 was made by Camerer, in 1880, in Reidlingen. The subject was his daughter, 12 years of age, and weighing 26.3 kilograms. The time was 4 days. It was the investigator's intention to make the time 6 days, but the milk became so distaste-

¹The Chemical Composition and Nutritive Value of Food Fishes and Invertebrates, by W. O. Atwater. Report U. S. Commissioner of Fish and Fisheries, 1888, pp. 679-868. Washington, 1891.

²Ztschr. Biol., 1879, 135.

ful that it was discontinued. A little coffee was used with the milk, but is not taken into account, as the quantity of solid matter would have been very small. In the original account nothing is said of the separation of the feces. Analyses of dry matter, casein, fat, and ash of the milk, and of the dry matter, nitrogen, fat, and ash of feces, were made in the laboratory of Hufner, in Tübingen.

No. 10 was made by Prausnitz in the laboratory of the Physiological Institute in Munich, in 1889. The subject was the laboratory servant who had been so often used in Rubner's experiments. His weight was 74 kilograms. The time was 3 days. The only food was milk. This was purchased in quantity, thoroughly mixed, put into little flasks, and sterilized by heating for 2 hours in a Koch steam sterilizer. The milk was kept in the flasks on ice, and slightly warmed before it was used. The separation of the feces was made by eating meat before and after the experiment. Determinations of dry matter, casein, total protein, nitrogen, fat, sugar, and ash in the milk were made; and of dry matter, nitrogen, ether extract, and ash in the feces.

Prausnitz's work bears out Rubner's statement that the amount of matter undigested by adults is larger in milk than in any other animal food. As Prausnitz says, "The presence of larger quantities of nitrogen in the milk feces does not of necessity mean that the protein of milk is not all digested. The nitrogen might be derived from digestive juices excreted with the undigested residue. This consideration does not affect the value of milk as a food. It is one of the most convenient, useful, and at the same time inexpensive sources of protein." He urges its use by the poorer classes.

No. 12 was made by Rubner in Munich, in 1877. The subject was a soldier, 23 years old, weighing 72 kilograms. The time was only 1 day. Rubner wished to make the experiment with cheese alone, but could find no one willing to live upon cheese without other food; therefore milk and cheese were used together. The cheese used was Allgäuer (similar to what is called "Swiss" cheese in the United States), and the dry matter, nitrogen, fat, and ash in it were estimated from analyses of cheese by Forster. The feces were analyzed. The separation was of course easily made. It is very noticeable that, though the quantity of solid matter, nitrogen, fat, and ash in the food was much larger than in the experiment of Rubner with milk alone, the quantity of solid matter, nitrogen, ether extract, and ash in the feces was not large. Rubner considers that this may be due to the fact that when milk is the sole article of diet its casein forms large masses in the stomach. The mechanical effect of the small pieces of cheese is to make these lumps of casein smaller, and hence more easily acted upon by the digestive juices.

No. 14 was made by Rubner in Munich, in 1878. The subject was the laboratory servant above mentioned. He was then 43 years of age, and weighed 74 kilograms. The time was 2 days. The food was bread made from fine wheat flour. The dry matter, nitrogen, and ash in the flour and yeast were determined by analysis, and the results were used in computing the composition of the bread, which was made in the physiological institute where the experiments were carried on. The feces were analyzed. The method of separation of the feces was not stated, but presumably milk was used before and after the experiment. The quantity of the solid excrement was not large, but contained more nitrogen than that from animal foods. The nitrogen balance showed that the subject lost nitrogen at the rate of 3.4 grams per day.

No. 16 was made by Meyer in the same laboratory, in 1869. The subject was a healthy young man. The age and weight were not stated. The time was 4 days. The food was rye bread, made in Munich. Some coarse wheat flour was mixed with the rye, and the bread was leavened. To make the bread more palatable, 50 grams of butter were eaten with it, and 2 liters of beer per day were used as a beverage. The separation of the feces was made by a diet of meat before and after the experiment. Dry matter, nitrogen, and ash were determined in the bread and feces. The subject had a feeling of hunger during the experiment, though the quantity of bread eaten was rather large.

Nos. 18 and 19 were made by Menicianti and Prausnitz in the same laboratory, in 1892. The time of each was 3 days. The subject was a physician, 25 years old, weighing 85 kilograms. In No. 18 the food was entirely bread made of wheat and rye flour with yeast. In No. 19 the bread was made of part of the same flour, but was leavened. Full analyses of the bread and feces were made. The separation of the feces was made with milk.

The flour was ground especially for the investigators, and the bread made under their supervision. The utmost care was taken in all details.

The object of the two investigations last named was to observe the effect of the different processes of bread making upon digestibility. The process of leavening is still much used in Europe. Dough is kept from one baking until the next, and this "leaven" is used instead of yeast. An opinion prevails in England that leavened bread is not as palatable as bread made by other processes.¹ The leavened bread in this experiment gave a larger undigested residue than that made with yeast. In Prausnitz's opinion this may be due to the fact that the presence of larger quantities of bacterial cleavage products in the leavened bread caused a greater excretion of intestinal juices and this effected the increase in weight of the metabolic products in the feces.

No. 20 was made by Rubner in Munich in 1877. The subject was a Bavarian soldier who was accustomed to a diet consisting largely of potatoes. The time was 2 days. The food consisted of potatoes, which were boiled and eaten with salt or butter, or with oil and vinegar as salad. It is not stated whether analyses were made of the potatoes or whether the composition was estimated from other analyses. Analyses of dry matter, nitrogen, ether extract, and ash in the feces were made. The separation of the feces was by means of a milk and cheese diet. The nitrogen was poorly digested and the body lost nitrogen at the rate of 1 gram per day.

Nos. 21 and 22 were made by Breuer in the Munich laboratory in 1878, and reported by Rubner. Breuer was himself the subject; his age and weight are not stated. The time in No. 21 was 2 days; in No. 22 it was 3 days. The vegetables, carrots in No. 21, Savoy cabbage in No. 22, were in each case the only food. The same method was followed in the preparation of both; the fresh vegetable was cooked in water with salt and fat for one-half hour in a covered vessel. The separation of the feces was by means of a milk diet. Analyses of the vegetables and of the feces were made. It was the intention of the investigator to continue the carrot diet for 3 days, but it became so distasteful that this could not be done. In the case of the carrots the fat was well digested and the carbohydrates very poorly. In each case the body lost nitrogen; with carrots 8.5 grams per day, and with Savoy cabbage 6.9 grams per day.

No. 23 was made by Rubner in Munich in 1876. The subject was a medical student 22 years old. The time was 2 days. The food was fresh green beans, (presumably "string beans") which were cooked in water with some butter. Whether analyses of the beans were made or not is not stated, but it seems probable that they were. The feces were analyzed. Rubner remarks that too much value should not be placed on this experiment, since the quantity of solid matter in the diet was too small to serve in any adequate manner as food.

No. 25 was made by Rubner in Munich in 1879. The subject was the laboratory servant above mentioned. The time was 2 days. The food consisted of peas which were purchased dry, carefully cleaned, and cooked in water 2 or 3 hours. They were then soft and were pressed through a fine sieve. Salt was eaten with the peas and 1 liter of beer per day was used as a beverage. Full analyses of the peas and of the feces were made. The chief point of interest in this investigation is the digestibility of the nitrogen. In common with other vegetable foods peas contain a large percentage of undigested nitrogen, but they rank among the best of vegetables as a furnisher of nitrogen.

¹Jago. Chemistry of Wheat Flour and Bread and Technology of Breadmaking, p. 328.

No. 27 was made by Strümpell, who was himself the subject, and is quoted from König.¹ The food consisted of lentils, a very common food material in Europe. They were soaked in water and then boiled. The nitrogen was much less thoroughly digested than in dry peas or beans, but it seems probable that if more experiments were made the nitrogen would be found to be more digestible.

No. 28 was made by Prausnitz in the Munich laboratory (in 1889?). The subject was the laboratory servant mentioned above. The time was 3 days; the food white beans. These were soaked in water overnight and then cooked in salted water until soft. Some flour was browned in fat and this mixed with the beans, with addition of a little vinegar and some of the water in which the beans were cooked. Analyses were made of the beans and of the feces. The chief interest in this experiment attaches to the digestion of the nitrogen. The amount undigested, 30.3 per cent, is much larger than in the experiment with peas; but it must be remembered that the peas were eaten in the form of a mush, while the beans were, for the most part, whole. This might have a considerable influence on the digestibility.

Nos. 29, 30, and 31 were made by Malfatti² and are quoted from König. The subject was a man 20 years old weighing 75 kilograms. The food in No. 29 was maize meal cooked into a mush with water. In No. 30 butter and in No. 31 cheese was added to the meal. Maize meal cooked in this way either with or without butter or cheese is much used in northern Italy under the name of polenta. It forms almost the sole food of a large class of the poor people. The quantity of nitrogen in the maize meal is not large but it is very well digested.

No. 32 was made by Rubner in Munich in 1876. The subject was a medical student 22 years old, weighing 72 kilograms. The time was 2 days. The food was maize meal cooked to a mush with water and butter, with addition of grated Parmesan cheese. The subject of the experiment did not relish the food thus prepared and after the first meal made of it, meat extract was added; 1,250 centimeters of beer daily were used as a beverage. The composition of the food was estimated from König's compilation of analyses. The feces were analyzed. The digestibility of the nitrogen, fat, and ash agree quite closely with No. 29. The body lost 2.2 grams of nitrogen per day.

No. 34 was made by Rubner in Munich in 1877. The subject was the same as in No. 32. The time was 3 days. The food was rice which was cooked in water, or water and meat extract; a little fat and salt were added. Analyses of the food were not made, but the composition was estimated from the figures of König and others. The feces were analyzed. The separation of the feces was by means of a meat diet at the beginning and milk at the end of the experiment. The body lost 3.2 grams of nitrogen per day.

Nos. 35 and 36 were made by Mayer at Wageningen, in Holland, in 1882. The subject was a man 39 years old, weighing 70 kilograms. The time in each case was 1 day, but three of these trials of a day each were made with each material. The object of the experiments was to test the comparative digestibility of butter and oleomargarine. Each was eaten in a diet which was otherwise practically the same in all three trials. It consisted of bread, peas, potatoes, condensed milk, egg albumen, sugar, cheese, and beer, and contained little fat aside from the butter or oleomargarine. In No. 35, 72 grams of butter, containing 60.5 grams fat, and in No. 36, 70 grams oleomargarine, containing 63 grams fat, were eaten. The fat in the butter was determined. The nitrogen, fat, ash, and carbohydrates of the food were calculated from analyses. Ether extract of the feces was made. The butter came from a farm in Holland and the oleomargarine from a manufactory in The Hague. The natural butter was slightly better digested than the artificial. The same difference is seen in Nos. 37 and 38, which are averages each of three practically identical experiments. The little fat in the diet, aside from the two sorts of butter, comes

¹ König quotes from *Centbl. med. Wiss.*, 1876, p. 47.

² *Sitzungsber. Wien. Akad. Wissensch.*, 1884, vol. 110, III part.

largely from the condensed milk, and so is really the same as butter fat, and should not affect the results materially. It is very probable that the ether extract in the case of butter was entirely composed of metabolic products, coloring matter, etc. The coefficient of digestibility of butter fat would then be 100 per cent. If the same amount of coloring matter were excreted in the experiment with oleomargarine its digestibility would be 98 per cent. For all practical purposes oleomargarine would thus be as digestible as butter.

No. 39 was made by Rubner, in Munich, in 1877. The subject was the laboratory servant mentioned above. The time was 2 days. The object of the experiment was to observe the quantity of fat which could be digested. The fat was given in a practically constant mixed diet consisting of bread and meat. Whether analyses of the food were made or whether its composition was calculated from known figures is not stated. The feces were analyzed. The separation was made by means of a milk diet. In No. 39, 100 grams of bacon (with 95.6 per cent fat) were eaten. The excreted fat was 17.2 grams, or 17.4 per cent of the amount consumed. Three other experiments, with larger quantities of fat, were made. These are tabulated with No. 39 for convenience.

Comparative digestion of fat when taken in different quantities.

No.	Kind of fat eaten.	Fat in food.	Ether extract in feces.	Ether extract in feces.
		<i>Grams.</i>	<i>Grams.</i>	<i>Per cent.</i>
39	Bacon (95.6 per cent fat)	100	17.2	17.4
a	Bacon (95.6 per cent fat)	200	15.2	7.8
b	Butter	240	5.8	2.7
c	{ Bacon (95.6 per cent fat)	145.8	} 44.6	12.7
	{ Butter	233		

It will be seen that when a large quantity of fat was consumed the excreted quantity was large. It is also noticeable that butter was more digestible than bacon. Rubner remarks that this is very likely due, in part, to the fact that the butter is more thoroughly acted upon by the digestive juices, since it is in a finely divided condition. The feces contained small pieces of bacon which had evidently not been disintegrated and were unchanged. The fat in the bacon is also inclosed in fat cells, and hence less easily attacked.

No. 40 was made by Constantinidi in the Munich laboratory in 1886. The subject was the laboratory servant mentioned above. The time was 3 days. The diet consisted of potatoes, cooked in water to which fat was added, and "gluten," a vegetable proteid compound made from waste products of wheat. Beer was used as a beverage. The food and excreta were analyzed. The separation of the feces was effected by means of milk. The object of the investigation was to see if the vegetable protein would furnish a fair substitute for animal protein, as ordinarily consumed in meat, or any other expensive protein substance. The nitrogen in the feces was only 6.4 per cent of the whole. The body made a daily gain of 3.6 grams nitrogen. When a second experiment was made like the above, but without the gluten, the body lost 2.3 grams of nitrogen per day. The gluten furnished, therefore, a valuable and cheap nitrogenous food.

No. 41 was made by Mori, in the laboratory of the Physiological Institute in Tokio, Japan. He was himself the subject; his age was 23 years, and his weight 52 kilograms. The time was 6 days. The diet consisted of boiled rice, bean cheese, vegetables (potatoes, etc.), salted radish, and fish. This is a typical diet of Japanese of the middle classes to-day near the coast, and before European influence was so pronounced in Japan, was very widespread among even the better classes. The food and excreta were analyzed. It will be seen that the food was well digested. The nitrogen balance showed a daily gain of 0.9 grams nitrogen by the body.

No. 42 was made by Manfredi, in the laboratory of the Hygienic Institute of the University of Naples, in 1892. The time was from 3 to 7 days in the different trials. The subjects were poor people in Naples. Eight studies were made. Full details of the food are given in the chapter on dietaries, page 195. The food and excreta were analyzed. The separation was made by means of grapes. The skins and seeds are excreted undigested and afford a means of identifying the food with which they were eaten, although the demarcation is less sharp than with lampblack or milk. Determinations of crude fiber in food and feces were also made.

Nos. 46 and 47 were made by Voit, in the Munich laboratory, in 1886. The subject of No. 46 was an upholsterer, 28 years old, weighing 57 kilograms. The time was 14 days, and divided into periods of 5, 5, and 4 days. The subject of No. 47 was a laboratory servant, weighing 74 kilograms. The time here was only 3 days, and the experiment can not be taken as of much value, as the food was so distasteful that it could only be eaten with difficulty. Details of No. 46 will be found under dietary No. 44, on page 192.

Nos. 48 and 49 were made by Mori, in Tokio, in 1888. Details of the diet will be found on pages 197 and 198.

No. 43 is included in the description of No. 40.

Nos. 50 to 58 were made by Prausnitz, in Munich, in 1892. They form a series with Nos. 18 and 19. The subject in Nos. 18, 19, 52, 54, 55, and 57 was a physician 25 years old, weighing 82 kilograms. The subject in Nos. 50, 51, 53, 56, and 58 was a laboring man 34 years old, weighing 85 kilograms. The time was in each case 3 days. As was stated under Nos. 18 and 19, the object of these experiments was to test the digestibility of various kinds of bread made with yeast and leavened. Full analyses of food and feces were made, including crude fiber. The quantity of crude fiber in the bread was small, 3.9 to 8.9 grams per day, and it was in general about half digested.

The attempt is made in Table 13, herewith, to epitomize the results of the experimental inquiry above detailed. The coefficients of digestibility of the nutrients, especially in the cases of protein and fat, are somewhat higher than the corresponding figures in Table 11, the reason being that allowance is made in Table 13 for the metabolic products. Of course such figures as these are only estimates. Probably more reliance can be placed upon the coefficients of animal than upon those of vegetable foods. The figures for the digestibility of the protein of vegetable foods are doubtless nearly accurate, those of the carbohydrates reasonably so, and those of the fats least reliable and in some cases of very little value.

TABLE 13.—*Digestibility of nutrients of food materials.*

Animal foods.	Percentages digested.			Vegetable foods.	Percentages digested.		
	Protein.	Fat.	Carbohy- drates.		Protein.	Fat.	Carbohy- drates.
	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>		<i>P. ct.</i>		
Beef and veal.....	100	95		Wheat flour, fine	85	} 80 per cent assumed for all.	} 95 per cent assumed for all.
Mutton.....	100	95	.....	Wheat flour, medium...	81		
Pork	100	95	.....	Wheat flour, coarse....	75		
Fish and oysters	100	95	.....	Rice.....	85		
Milk	100	96	100	Macaroni.....	85		
Cheese	100	95	100	Rye flour.....	78		
Butter.....		96	.....	Maize meal.....	85		
Oleomargarine		95	.....	Potatoes.....	75		
Tallow		95	.....	Cabbages, turnips, etc..	80		
Lard		95	.....	Beans	85		
Oils		95	.....	Peas.....	85		
Eggs	100	98					

Table 14 exhibits, for a number of food materials, the proportions of nutrients which are estimated to be digestible. It was computed by applying the figures in Table 13 to the figures for composition of food materials in Table 2, above. Thus, in beef the whole of the protein (100 per cent in Table 13) is assumed to be digestible. The average of the analyses of shoulder of beef, epitomized in Table 2, gives 19.5 per cent of protein. This is, accordingly, the percentage assumed to be digestible. In wheat flour 85 per cent of the total protein is estimated to be digestible, the remainder, 15 per cent, being undigestible. The wheat flour of Table 2 contains 11 per cent of protein. Accordingly 9.4 per cent will be digestible and 1.6 per cent undigestible.

TABLE 14.—*Estimates of proportions of digestible and undigestible nutrients in food materials.*

Food materials (edible portion).	Protein.			Fats.			Carbohydrates.		
	Digest ed.	Undi-gested.	Total.	Digest ed.	Undi-gested.	Total.	Digest ed.	Undi-gested.	Total.
Beef:	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>
Shoulder	19.5	.....	19.5	14.8	0.8	15.6	.....	.....	.....
Sirloin	18.5	.....	18.5	19.5	1	20.5	.....	.....	.....
Round	20.5	.....	20.5	9.6	.5	10.1	.....	.....	.....
Veal, shoulder	20.2	.....	20.2	9.3	.5	9.8	.....	.....	.....
Mutton:									
Shoulder	18.1	.....	18.1	21.2	1.1	22.4	.....	.....	.....
Loin	15	.....	15	33.3	1.7	35.0	.....	.....	.....
Pork:									
Shoulder	16	.....	16	31.2	1.6	32.8	.....	.....	.....
Very fat	.9	.....	.9	78.7	4.1	82.8	.....	.....	.....
Eggs	14.9	.....	14.9	10.3	.2	10.5	.....	.....	.....
Milk	3.6	.....	3.6	3.8	.2	4	4.7	.....	4.7
Butter	(?)	(?)	1	81.6	3.4	85	.5	.....	.5
Cheese:									
Full cream	28.3	.....	28.3	33.7	1.8	35.5	1.8	.....	1.8
Skim milk	38.4	.....	38.4	6.5	.3	6.8	8.9	.....	8.9
Haddock	16.8	.....	16.8	.3	.....	.3	.....	.....	.....
Bluefish	19	.....	19	1.1	.1	1.2	.....	.....	.....
Cod	15.8	.....	15.8	.4	.....	.4	.....	.....	.....
Shad	18.6	.....	18.6	9	.5	9.5	.....	.....	.....
Mackerel	18.8	.....	18.8	7.8	.4	8.2	.....	.....	.....
Halibut	18.3	.....	18.3	4.9	.3	5.2	.....	.....	.....
Salmon	21.6	.....	21.6	12.7	.7	13.4	.....	.....	.....
Wheat flour:									
Fine	9.4	1.6	11	.9	.2	1.1	71.1	3.8	74.9
Medium	9.5	2.2	11.7	1.4	.3	1.7	68.1	3.6	71.7
Cracked wheat	8.9	3	11.9	1.4	.3	1.7	70.9	3.7	74.6
Maize meal	7.8	1.4	9.2	3	.8	3.8	67.1	3.5	70.6
Rice	6.3	1.1	7.4	.3	.1	.4	75.4	4	79.4
Potatoes	1.6	.5	2.1	(?)	(?)	.1	17	.9	17.9
Turnips	1	.2	1.2	(?)	(?)	.2	7.8	.4	8.2
Beets	1.2	.3	1.5	(?)	(?)	.1	8.5	.4	8.9
Wheat bread	7.1	1.7	8.8	1.4	.3	1.7	53.4	2.8	56.2
Rye bread	6.5	1.9	8.4	.4	.1	.5	56.7	3	59.7
Graham bread	7.1	2.4	9.5	1.1	.3	1.4	50.6	2.7	53.3

FURTHER CONSIDERATIONS REGARDING DIGESTIBILITY.

The estimates of coefficients of digestibility above made, as well as the statistical data upon which they are based, apply to the quantities of nutrients digested by healthy individuals from wholesome food properly cooked and masticated. They do not in any way explain the reasons for the differences of digestibility of the nutrients in different kinds of food materials. They throw but little light upon the ease and time of digestion and the fitness of the digested matters for the user.

As to the reasons for the differences of digestibility, but comparatively little is definitely known. There are, however, certain *a priori* considerations which help toward explaining them. For example, the digestibility of the proteids is discussed by Prof. R. H. Chittenden, as follows:¹

If of two foods possessing a like composition one be more easily digestible, that one, though containing no more available nutriment than the other, is in virtue of its easier digestibility more valuable as a food stuff, and in one sense more nutritious, as well as more economical for the system. The ease with which a proteid food can be utilized to supply the needs of the body depends, therefore, not only upon its intrinsic qualities, viz, whether it has been derived from the animal or vegetable kingdom, and upon its chemical and other peculiarities, but also, to a great extent, upon the way in which it has been prepared for digestion.

Proteid foods are rendered available for the needs of the body mainly through the action of the digestive juices. These convert the insoluble food stuffs into soluble and diffusible products, capable of being directly absorbed by the circulating blood. The two juices having this functional power are the gastric and pancreatic fluids, the former performing its work in the stomach and the latter in the small intestine. Both accomplish essentially the same object in a somewhat different manner, viz, the conversion of the insoluble proteids into soluble albumoses or proteoses and peptone, which are taken up from the alimentary tract by the blood and distributed to all parts of the body, where they may be utilized according to their several functions in nutrition. It is thus easily conceivable that while one class of proteid food stuffs may be somewhat resistant to the digestive action of the acid gastric juice, it may be more readily attacked by the alkaline pancreatic juice, or the reverse may be true. In any event, the full utilization of the ingested food stuff by the system depends in great part upon the completeness of its digestion by these two digestive fluids.

As a general rule the proteids of animal origin, as of beef, mutton, eggs, etc., are more easily digestible than those derived from the vegetable kingdom. This is partially due to the nature of the animal proteids; but another factor of even greater moment is the large admixture of extraneous matters ordinarily associated with vegetable proteids. Thus, oatmeal, wheat flour, potatoes, etc., contain a comparatively small amount of proteid matter, admixed with a large bulk of starchy material and some cellulose. Hence, in a purely vegetarian diet, a large bulk must be consumed in order to obtain even the minimum amount of proteid food required. In other words, the nitrogenous or proteid matter is so diluted by large masses of cellulose and starch that an excess of work is thrown upon the alimentary organs, which not only causes discomfort, but is a physiological loss, entailing the working over by the system of large quantities of material in order that the required amount of proteid matter may be obtained. By this it must not be understood that vegetable food is undesirable, for such is certainly not the case. Starchy foods are particularly valuable and a necessary part of a normal diet, the cereals especially, when properly prepared, being very completely digested and absorbed; but it is physiologically injudicious to depend entirely upon vegetable food for the necessary proteid matter. The latter is far more economically (from a physiological standpoint) obtained from animal foods, where it exists not only in a much more concentrated form, and as a consequence is more readily digestible, but the proteid matter itself is more quickly and completely assimilated than the vegetable proteid, even under equally favorable circumstances.

It is a well-understood fact, however, that the digestibility and best utilization of food depends greatly upon a reasonable variation in the character of the dietary.

¹The Rumford Kitchen Leaflets, No. 3.

Too great sameness, especially if long continued in, may even lead to an actual impairment of the digestive organs. Hence the instinctive desire common to mankind in general for variety in the daily diet rests upon physiological grounds well worthy of recognition.

One of the most important conditions modifying the digestibility of animal proteid foods is the manner in which the muscle fibers are bound together, determining, as it does, the extent of their mechanical subdivision on reaching the stomach. Thus, in the various kinds of meat the short and delicately fibered muscles are obviously more readily digestible than the longer and tougher fibers, which plainly offer greater resistance to disintegration. It is on this account that the breast of a young chicken, for example, is so easily digestible, the short, tender fibers easily breaking apart and thus exposing more surface to the action of the digestive fluids. For a similar reason the short, flaky muscles of the more digestible varieties of fish are easily assimilated. Further, the presence or absence of fat exercises a marked modifying influence upon digestibility; as a general rule it may be said that lean meat is more readily digested, in the stomach, at least, than fat meat, although the nature of the fat present and the manner of its distribution are important factors. Thus, the presence of a hard or difficultly fusible fat, as in mutton, tends to retard the digestion of the proteid constituents of the meat more than the presence of a softer or more readily fusible fat, such as is found in beef. Again, the intimate mingling of fat with the individual muscle fibers, as in the tissues of the eel and lobster, tends to check the rate of digestibility. The same effect is seen in certain kinds of fish flesh; thus, in the shad the white meat, with its greater freedom from incorporated fat, is nearly 10 per cent more digestible than the dark and fatter meat of the same fish.

EFFECTS OF PREPARATION OF FOOD UPON DIGESTIBILITY—COOKING.

The effect of the preparation of food, and especially its cooking, upon its digestibility is a subject about which much is written and little definitely known. Here again, as in the case of the differences in digestibility of different substances, our present knowledge comes mainly from a priori considerations. The experimental data are unfortunately very meager.

The chief underlying principle is the same as that involved in the dissolving of the ore in the illustration given above. If the particles of ore are large the acid will act on them slowly. Stirring hastens the solution of the soluble materials. Time is needed for those that are slow to dissolve. If the particles of ore are incased in siliceous or other insoluble matter thorough disintegration is necessary, so that the acid may come in direct contact with the material to be dissolved. So in the digestion of food meat is cut into small pieces and chewed into still finer ones; grains of wheat which can not be well chewed are first ground. Milk requires neither cooking nor chewing. Its nutrients are either already in solution or suspension in very finely divided portions. It has no starch to be changed into sugar by ptyalin. Its only carbohydrate, milk sugar, is already dissolved; we accordingly drink it raw. Many kinds of meat are found by experiment to be digested as readily or even more readily when taken raw than when cooked, provided they are properly masticated, i. e., finely chewed; but we like their taste better, and are more inclined to masticate them properly when well

cooked. The flavor induced by cooking excites the secretion of digestive juices which corresponds to the addition of acid to the dissolving ore. Furthermore, by cooking the connective tissue of some of the tougher meats is disintegrated. The collagen which serves as the binding material is changed to more or less soluble gelatin, the meat is made tender and can be chewed more finely, the further disintegration in the alimentary canal is facilitated, and the proteids and fats are more perfectly exposed to the solvent action of the digestive juices.

The following remarks of Professor Chittenden bear directly upon this subject:¹

More important from a dietetic standpoint is the effect of cooking or preparation of proteid foods on their digestibility, and in this connection it must be remembered that digestion in the broad sense of the word is a complex process, dependent upon the harmonious working of several closely allied processes. By way of illustration it may be mentioned that a given food stuff may owe its lack of digestibility either to an inherent resistance to the solvent action of the digestive juices or more directly to the fact that its ingestion fails to cause the requisite flow of the necessary digestive secretion. Now, one of the effects of cooking is to improve, or rather develop, an agreeable flavor in the food, thus increasing its palatability and causing a pleasurable stimulation of the sense of taste. This at the same time leads to a greater outpouring of the needed digestive juices, thus furnishing the means for more rapid and complete digestion. Further, the very increase in palatability incidental to proper and intelligent cooking leads to a more thorough mastication of the proteid food, while at the same time the cooking tends to facilitate its separation and mechanical subdivision. This latter, as already stated, greatly aids the digestive process by enabling the different digestive secretions to come into more intimate contact with the individual particles. This tendency toward disintegration and general softening incidental to cooking is due mainly to the complete or partial hydration of the connective tissue fibers by which the muscle tissue is held together into gelatin, which is far more readily digestible and assimilable than the collagen itself.

In all methods of cooking meats, as indeed all forms of proteid food, whether by boiling, roasting, or broiling, the proteid or albuminous matter undergoes more or less complete coagulation. This, however, is essential in any process of cooking by which a rich and appetizing flavor is to be developed, and if not accomplished at too high a temperature offers no obstacle to easy digestibility; indeed, it has already been stated, owing to the conversion of the collagen of the surrounding connective tissue, digestibility may be even increased. At the same time, it is well to remember that raw beef, for example, if very finely divided by chopping, is somewhat more easily dissolved by the gastric juice than when coagulated by cooking. All things considered, however, proper cooking unquestionably tends to increase the general digestibility of proteid foods. At the same time it alters the consistency and constitution of the food stuff, joining to it an odor and taste which would otherwise be wholly lacking, and, no less important, causes the destruction of disease germs or other related organisms possibly present.

The many methods of preparing proteid foods for consumption need hardly be considered here; they have little bearing on the direct digestibility of the various food stuffs, except so far as they modify the degree of coagulation of the proteid matter, the mechanical subdivision of the tissue, and the removal or addition of admixed fat. More important, however, is the indirect effect on digestibility incidental to the degree of palatability produced, with the corresponding degree of stimulation of the secretory processes by which digestibility is so greatly augmented.

¹ Loc. cit.

Palatability and digestibility go hand in hand, and the intelligent preparation of a so-called cheap or tough piece of meat, for example, may result in as digestible and nutritive a product as the more careless preparation of a piece of tenderloin.

Some interesting experiments upon the rapidity of digestion of meats, cooked and uncooked, and of milk in various forms, have been conducted by Jessen at Tübingen.¹ They were made by the methods of artificial and natural digestion, those of the latter kind being performed with a dog and with a man.

To test the effect of cooking lean beef, portions were finely chopped and the tendons and other connective tissue were separated as completely as practicable. The material thus prepared was divided into several parts. One part was left raw, others were boiled, and still others were roasted. Of the boiled and roasted portions some were rare, or, as Jessen calls them, "half done," and others well done. The raw, half-done, and well-done portions were tested by artificial digestion with pepsin, by experiments in the stomach of a dog, and by experiments in the stomach of a healthy man. In the experiments by artificial digestion the meat was placed in glass tubes, an acid solution of pepsin was put upon it and the tubes with their contents were kept at about the temperature of the body for 24 hours, with occasional stirring. With the dog a fistule was used consisting of the usual metal tubes, permanently inserted through the skin into the stomach, and opened or closed with a stopper at will. The meat was inclosed in a cloth, inserted through the tube, and removed after the desired time. In the experiments with the man, a laboratory servant, the food was taken into the stomach when the latter was empty, and after digestion for the desired time, withdrawn by a stomach pump. The results of the experiments of the three kinds were essentially concordant. The raw meat was digested more readily than the cooked. In the trial by artificial digestion the residues unaltered by the pepsin were smallest with the raw meat and largest with that which had been most thoroughly cooked by boiling or roasting. In those with the man the digestion was completed in different lengths of time as set forth in the figures of Table 15, herewith. Similar trials were made with other kinds of meat and with milk. The results of the experiments with the man are summarized in Table 15.

TABLE 15.—*Relative time required for digestion of cooked and uncooked foods in a man's stomach.*

MEATS.		Hours.
Beef:		
Raw	.....	2
Boiled, half done	.....	2½
Boiled, well done	.....	3
Roasted, half done	.....	3
Roasted, well done	.....	4
Mutton, raw	.....	2
Veal, raw	.....	2½
Pork, raw	.....	3

¹ Ztschr. Biol., 1893, p. 128.

MILK.

	Hours.
Cows' milk, 602 cubic centimeters:	
Uncooked.....	3½
Boiled.....	4
Sour.....	3
Cows' milk, 675 cubic centimeters, skimmed.....	3½
Goats' milk, 656 cubic centimeters, uncooked	3½

It will be seen that the raw veal required somewhat longer time for digestion than the mutton, and that the pork, which doubtless contained a larger percentage of fat, was still slower in digestion. The boiled milk was digested somewhat more slowly and the sour milk a little more quickly than the uncooked milk.¹

It should be insisted that the experiments of this kind, of which the number on record is small, do not suffice for satisfactory generalizations. They can not be taken as exact measures of the degrees of digestibility of the different materials. It should be born in mind, furthermore, that they apply only to what takes place in the stomach; while the normal process of digestion goes on in the intestines after the food has left the stomach. At the same time, these results are the more worthy of confidence because they accord with the chemistry and histology of the subject.

It is a familiar fact that tough meats are made tender by long heating at a comparatively low temperature. The best explanation of this is, perhaps, to be found in the disintegration of the connective tissue with the formation of gelatin. Unquestionably the principle is an important one in its practical applications.

Vegetable foods often require cooking to fit them for use. This is especially true of starchy foods, such as wheat, corn, beans, peas, and potatoes. The starch is contained in cells, the walls of which are acted upon comparatively slowly by the digestive juices. By cooking the cells are disrupted and the starch itself undergoes more or less of a chemical change, so that it is more easily and completely acted upon by the digestive ferments.

EFFECTS OF FOOD ADJUNCTS ON DIGESTION—FLAVORING MATERIALS.

A great deal has been said, much has been written, and a small amount of accurate experimenting has been done upon the effects exerted upon the digestion of food by food adjuncts, such as spice, mustard, and other flavoring materials; beef tea and meat extract; tea, coffee, chocolate, and similar beverages, and alcoholic drinks. Professor Forster, in speaking of what the Germans call "Genussmittel"—appetizers is perhaps the nearest corresponding word in English—the materials which are taken with food either for their own agreeable flavor or to

¹ See summary of later experiments on the digestibility of milk in Experiment Station Record, 5, pp. 959, 960.

improve the flavor of the food and which are often supposed to help digestion, says in substance, as follows:¹

There is no doubt that the human digestive apparatus can be excited to activity in various ways with Genussmittel, including such as are used by man in a refined civilization, at the beginning and end of his meals, e. g., meat broth, salt and salt condiments like caviar, cheese, etc. * * * We know that when brought into contact with the mucus membrane of the stomach and intestines of a living animal, they cause the filling of the blood vessels and secretion of the digestive juices. Sugar and salt are hardly brought into the mouth before they excite abundant effusion of saliva. Indeed, the same effect is produced even by the sight or smell of savory foods, and some of the well-tasting substances may act upon the digestive apparatus and its glands by simply being taken into the blood circulation. Thus, I have observed experimentally a rich secretion of gall after an injection of a solution of sugar into a vein (*vena mesenterica*). * * * It is very natural to infer from this that the work of digestion will go on better with the aid of such condiments than without them, in two ways: Either more nutriment might be digested from the same food, or, if there were no increase in the amount digested, it might be digested more quickly with their help, which would likewise be a gain. * * * But, important as this may seem to physiologists, it is of minor consequence with healthy persons. Thus, in experiments made with a man under my direction, when meat had been treated with water [to remove the "extractives" which give meat its flavor and which are the chief constituents of beef tea and meat extract] and was so tasteless as to be eaten in any considerable quantity with difficulty, the quantity digested and observed to pass into the circulation was as large as with the same weight of meat roasted in the ordinary way; and both Bischoff and Hofmann have found that meat extract taken with bread or with a mixed diet did not materially affect the digestion. And in experiments by Flügge with a mixed diet so tasteless as to make it, when continued some time, extremely repugnant, so that great effort was required to eat it, the digestion seemed to be unaffected thereby.

For the sick and convalescent, on the other hand, the effect of these appetizers upon the digestion is of great importance, especially where the digestive apparatus has been for a time more or less inactive and requires stimulating. Thus the observations of Kemmerich show the usefulness of bouillon and meat extract in case of enfeebled digestion.

In the case of the ore, there must be plenty of acid or it can not dissolve. If the supply of digestive juices is insufficient the food can not digest. The chief use of these food adjuncts would seem to be to stimulate the production of digestive juices. The results of later experimental inquiry and the teaching of the most reputable physiologists seem to be in line with the experiments here quoted. It would thus appear that while the materials which we call appetizers may often be very helpful where digestion is enfeebled, they are, for healthy people, unnecessary and without very great effect upon the utilization of food in the body. This subject, however, is one upon which we should speak with the greatest caution. In the present state of experimental knowledge categorical assertions are hardly justifiable. It is easy to cite statistics upon the quantities of nutrients digestible from different food materials, but all discussion of the effects of condiments, stimu-

¹In the volume on Ernährung und Nahrungsmittel, of Pettenkofer and Ziemssen's Handbuch der Hygiene.

lants, and cooking upon ease or time of digestion—and these are the most essential things from the hygienic standpoint—must be of that general and indefinite character which is most unsatisfactory to the careful student and investigator.

As to the effect of the quantity of food upon the proportions digested, the experiments at hand seem to point to the interesting conclusion that when a moderate amount is taken it is digested more completely than a very large, or, at times, even a very small quantity; so likewise a moderate amount of water taken with the food seems favorable, while too much has been found to interfere with digestion. As to the effect of moderate exercise just after eating, observations differ, some experiments indicating that muscular labor retards digestion, others that it does not. During sleep digestion has been found to be diminished. But the conditions upon which a proper answer to such questions depends are so complex and the definite knowledge is so limited that their discussion is neither easy nor agreeable.

SUMMARY.

In considering the digestibility of food we have to take into account (1) the quantity digested, and (2) the ease and time of digestion. As regards the quantities digested from reasonable amounts of ordinary food materials by healthy people, the best experimental evidence indicates that:

(1) The protein of our ordinary meats, fish, and milk is very readily and completely digested. The protein of vegetable foods is much less completely digested than that of animal foods. Of that of potatoes and beans, for instance, a third or more may escape digestion, and thus be useless for nourishment.

(2) Much of the fats of animal food may at times fail of digestion. This is presumably true of vegetable fats, but the quantities are in general so small that the determinations of the proportions digested are not very accurate.

(3) The carbohydrates, which make up a large part of vegetable food, are in general very digestible. The crude fiber or cellulose is an exception, but the quantities of this in the materials used for the food of man are too small to be of importance. Sugar is believed to be completely digested. This is assumed to be the case with the sugar of milk. The other carbohydrates of animal foods are very small in amount.

(4) The animal foods have in general the advantage of the vegetable foods in digestibility, that they contain more protein and that their protein is more digestible.

(5) The quantity digested appears to be less affected by flavor, flavoring materials, and food adjuncts, and to differ less with different persons, than is commonly supposed.

Concerning the relative ease and time of digestion of different foods, and consequent comfort and health, the lack of accurate experimental

data renders it more difficult to make concise statements. Cooking and other conditions are very important. Very much depends upon the individual peculiarities of different people.

SUGGESTIONS AS TO EXPERIMENTAL WORK NOW NEEDED.

To promote a better understanding of the digestibility of different kinds of food by different individuals several lines of inquiry need to be prosecuted. They have to do with:

(1) Artificial digestion.

(a) Improvement of methods.

(b) Actual tests of digestibility of different materials.

(2) Actual digestion.

(a) Investigation of metabolic products, their occurrence, nature, and amount.

(b) Improvement of methods.

(c) Systematic series of experiments on digestion.

Artificial digestion.—Concerning the experiments upon artificial digestion, it will suffice to say that what is now most pressingly needed is (1) a compilation of the results of inquiry already obtained, and (2) the elaboration of the methods of inquiry. These methods have, indeed, been worked out with no small degree of success, and it is now possible to make artificial tests of digestibility of various kinds of food materials the results of which agree tolerably well with the results of digestion tests by healthy men. But the conditions which affect digestion by the two methods are not yet well enough understood and the results by the artificial method as carried out to-day do not bring entirely accurate indications of the actual digestibility in the human organism. Of course similar remarks may be made regarding the artificial digestion of feeding stuffs and their natural digestion by domestic animals. The whole subject demands careful inquiry and promises most valuable results.

Actual digestion.—In experiments upon natural digestion by man, aside from the intrinsic difficulty of working with individual food materials, which become speedily distasteful and can not be endured by the average man for a very great length of time without danger of interruption of the normal digestive functions, the chief obstacle to the getting of accurate results is found in the metabolic products. It is greatly to be desired that investigations be made to learn more definitely what these materials are and in what quantities they are secreted under different conditions as to the characteristics of the individual and the kinds and amounts of food eaten. Reference was made above to experiments in which this subject has been studied. More inquiry is greatly needed. The investigations might be carried on some such plan as the following:

Suppose the question be, How much metabolic nitrogen will be excreted by a person of a given class, e. g., a healthy man, with a given

amount of food? A ration may be planned which shall consist mostly of fats and carbohydrates and shall contain only enough nitrogenous material to make it palatable. The nitrogenous material may consist of a material, like lean beef, which has been found to be almost, if not quite, completely digestible. The quantity of undigested nitrogen in such a ration will be extremely small and its amount can be estimated approximately from the experimental inquiry already made, and still more accurately if further investigations of the digestibility of meats accumulate. From the whole nitrogen excreted by the intestines that of the undigested residue can be subtracted and the remainder taken as the measure of the metabolic nitrogen. Of course it is desirable that the nitrogenous compounds in the excreta be separated and studied as far as practicable.

In like manner the quantities of fat, or, more properly speaking, ether extract, in the metabolic products may be approximately determined. For this purpose it is desirable to devise a ration consisting mainly of protein and carbohydrates with a minimum of fats and other materials which would be extracted by ether. The nature as well as the amount of these compounds in the food can be studied. Pains can be taken to be sure that they are in as digestible form as possible. The quantity of ether extract in the undigested residue will thus be reduced to a minimum, and some information as to its nature will be had in advance. The ether extract in the excreta can then be determined quantitatively and qualitatively. Comparison of the extracts in the food and excreta will throw light upon the nature and amounts of ether extract in the metabolic products. Of course other reagents than ether might be used for the extractions. "Ether extract" is here referred to because ether is the substance most commonly used in our present method of analysis.

The above suggestions indicate in a general way the manner in which the metabolic products can be studied. Of course the individual investigator will decide upon the details. It is, however, to be hoped that some cooperation between investigators in this line may be brought about.

Meanwhile it is possible to make tolerably accurate determination of coefficients of digestibility by the methods now in vogue. The quantities of metabolic products can be roughly estimated and allowance made for them in the summing up of the results. The time is ripe for a systematic series of experiments on the digestion of our ordinary food materials—meats, fish, eggs, milk, butter, cheese, bread, crackers, and other substances made from cereals, and potatoes and other vegetable products. It would not be difficult to plan such a series of experiments and to carry them out successfully, especially if the cooperation of a number of investigators could be secured.

CHAPTER V.

PREPARATION OF FOOD—COOKING.

What has just been said regarding the effects of cooking upon digestibility covers only a small part of the ground which needs to be traversed. Among the specific questions which need investigation are the temperature best adapted to the cooking of different materials in different ways—as roasting, frying, boiling, steaming, and stewing; the chemical changes involved in the process; the loss of nutritive material in preparing it for use; the effects upon flavor, palatability, and increase or decrease of digestibility. This represents a wide and useful field of inquiry, which is almost unexplored. How little is definitely known of this subject is illustrated by the fact that in the work of König on the Chemistry of Foods and Food Adjuncts, which is by far the most complete treatise upon this subject available, and which consists of two volumes, of nearly 2,600 royal octavo pages, only nine pages are given to the cooking of food. This chapter is, however, so interesting that the substance of it is given below.

PREPARATION OF FOOD—KÖNIG'S SUMMARY OF INVESTIGATIONS.¹

Uncivilized man takes his nourishment like animals—as it is offered by nature. Civilized man prepares his food before eating, and in ways which are, in general, the more perfect the higher his culture. The art of cooking, when not allied with a degenerate taste or with gluttony, is one of the criteria of a people's civilization.

The chief advantage of the preparation of food for eating is to facilitate digestion. This is accompanied by (1) adding condiments and giving it an agreeable appearance, so as to make it more appetizing, and thus increase the secretion of the digestive juices; (2) by loosening its texture and exposing it more fully to the solvent action which is the essential part of digestion.

EFFECTS OF CONDIMENTS UPON DIGESTION.

Flavoring materials and an agreeable appearance do not increase digestion directly, but act rather upon the nervous system, which, in turn, transmits the stimulus to the digestive organs and incites them to greater activity. While this may be helpful, it does not necessarily increase the amount actually digested from the food. Meat that has

¹Chemie der menschlichen Nahrungs-und Genussmittel. Von Dr. König. Dritte Auflage; II. Band, pp. 138-139, 605-611, 1244-1252.

been extracted by water and made entirely tasteless has, according to Foster and Rynders, been found in actual experiments to be as quickly and completely digested as an equal weight of meat roasted in the ordinary way; and the same is stated by Flügge to have been the case with a mixed diet so tasteless as to be repulsive. The principal condiments that influence digestive secretions are salt, sugar, alcohol, and spices.

Salt increases the flow of saliva and of gastric juice, hence one value of its use at meals in side dishes like caviar, olives, and pickles. The salting of food is so indispensable that salt is in some regions considered a necessity, and the lack of it has been a cause of war.

Sugar is very agreeable to the palate, and the mere thought of it often makes the mouth water; in other words it causes the secretion of saliva. Doubtless the flavor is the chief cause of the great demand for sugar, for although it is a valuable aliment, it hardly surpasses starch, dextrin, and other carbohydrates in nutritive value.

Alcohol.—Taken in moderate quantities in such forms as cognac, brandy, wine, beer, and other beverages, alcohol is likewise an important stimulant to digestion. Brandy, whisky, sherry, and the like are therefore favorite remedies in disturbances of the bowels and stomach, and this helps to explain why the poorer classes, who often live upon a wretched diet of the less digestible foods, such as coarse bread and potatoes, have a craving for strong and stimulating alcoholic drinks. It is the improper and excessive use of alcoholic beverages which makes them a scourge to man by weakening his digestive apparatus and undermining his general health.

At the same time it should be said that sugar and alcohol, until they are absorbed by the system, hinder, temporarily, the actual process of digestion, at least in the stomach. After their disappearance from there the digestion goes on more vigorously than if they had not been taken.

The influence of carbonated waters and salts is often very beneficial.

Spices.—Some of these act directly upon the glands which secrete the digestive juices, as is the case with pepper, which contains piperin, and with mustard, which contains an oil that increases the flow of bile. Others first delight the sense of smell, which then stimulates the flow of saliva. Such are vanilla, cinnamon, and cloves. A similar influence is exerted by onions, parsley, and the like, which contain aromatic substances. Fruits, likewise, contain, besides aromatic oils, more or less malic acid, which directly aids digestion.

Meat extract, tea, coffee.—These are stimulants, and, like wine and beer, excite more particularly the nervous system, and in so doing they are at times very useful. The stimulating agents in tea and coffee are alkaloids and essential oils; those in beer and wine are alcohol and fragrant ethers. Tea and coffee, taken in moderation, have no disturbing effect upon digestion.

EFFECTS OF COOKING UPON DIGESTIBILITY AND NUTRITIVE VALUE.

Cooking changes the texture of food, making it in some cases more and in others less digestible. In general, the digestibility of vegetable materials, as flour and potatoes, is increased, and that of animal foods, as meat, is diminished by cooking, though there are exceptions. Cooking can not add to the amount of nutritive material in food, except in so far as it may increase the proportion which is actually digested; but it may, and often does, remove considerable quantities, as in the boiling of meats.

We may consider the effects of cooking under different categories, as the boiling, broiling, and roasting of meats, the boiling and baking of vegetables, and the baking of bread.

BOILING, BROILING, AND ROASTING OF MEATS AND OTHER ANIMAL FOODS.

Boiling, as commonly understood, is heating in water. This is done generally with the water at or near the boiling point. But much cooking in water is done at a lower temperature, because the water is not always heated to the boiling point, and, more especially, because when meats and other materials are immersed in boiling water, as is usual in cooking, the heat does not penetrate so as to bring the temperature of the interior up to that of the water. On the other hand, there are cases where, as in the preparation of gelatin, the water and the meat or bone or other material are heated much above the temperature of boiling water.

Steaming is similar to boiling, the difference being that the material is surrounded by steam rather than water.

Boiling and steaming effect four kinds of change in the food. (1) It is made more soft and tender. In meats the connective tissue is softened, weakened, and, to a greater or less extent, gelatinized and dissolved, and thus the fibers of the meat are loosened. (2) Some material is made soluble. This is the case with the gelatinoid substance of meat as just stated, and especially with that of bone. By long boiling the albuminoid materials of meat are dissolved to slight extent. On the other hand, more or less of the albuminoids of meat, as the albumin and myosin, are coagulated and hardened by boiling. (3) Flavors are developed which make the materials, especially meats and fish, more agreeable to the taste, and hence tend to promote the secretion of digestive juices and thus aid digestion. (4) More or less material is dissolved out of the food by the water. When used for soup the dissolved materials are well utilized, otherwise they are lost.

Various experiments¹ have proved that boiled, roasted, or smoked meat, for example, is not as quickly and completely digested as raw meat. Our preference, then, for meat so prepared only shows how

¹ Chittenden and Cummins, *Am. Chem. Jour.*, 6, 318; M. Popoff, *Ztschr. physiol. Chem.*, 1890, 14, 524; A. Stutzer, *Centbl. allgem. Gesundheitspflege*, 1892, 59; Jessen, see above, p. 75.

much value we attach to the pleasing tastes, odor, and physical condition of our food.

The cooking of meats and fish in "dry heat," by roasting, broiling, or frying, likewise effects several kinds of change. (1) The albuminoids are coagulated. The result of this generally, though not always, is to harden the fiber more or less and thus make the flesh less easily and completely digestible, especially on the outside. (2) Flavors are developed which make the flesh much more palatable and tend to favor secretion of the digestive juices. Thus, while the heating tends to make the material less digestible, the effect may perhaps be counteracted in part by the providing of more of the ferments which digest the food. (3) More or less of the juices of the meat are driven out by the heating. These commonly are saved in roasting, but lost to a greater or less extent in boiling.

When meats and fish are heated, whether in roasting, broiling, frying, or even boiling, much water is driven off.

Boiling of meat.—Meat contains from 5 to 8 per cent of substances soluble in water, namely, albumen, meat bases (creatin, creatinin, sarkin, etc.), organic acids, glycogen, inosit, and salts. When meat is boiled with water albumen is rendered insoluble and remains in the meat tissue, or produces the scum floating upon the broth. Some connective tissue is transformed into gelatin and is dissolved; a part of the melted fat passes into the broth.

In boiling meat two methods are employed; either (1) the meat is placed in cold water, which is then heated more or less slowly to boiling and kept boiling for some time, or (2) the meat is put into water already boiling. The results differ. In the first case the cold water penetrates the piece of meat and extracts more or less of the juices and soluble constituents; upon boiling the albumen partly collects upon the surface of the liquid as scum. In the second case only a little of the soluble material is extracted. The albuminoids at the surface of the meat coagulate and form an impenetrable layer. This cooking prevents the extraction of the soluble materials, and the inner parts are left more or less juicy. Consequently, to obtain a strong, nutritious broth, consommé, or soup, we use the first method, warming the water slowly, but if the boiled meat is to remain juicy and is to be eaten as meat, the second method is followed. This view is confirmed by experiments of A. Vogel,¹ who found that meat cooked by gradual warming with cold water lost much nitrogen and gave a richly nitrogenous broth, while meat placed directly in boiling water retained its nitrogen and juice but yielded a poor broth.

As a general thing, however, meat is not completely extracted even in making soup, and bones are often boiled with it to secure a strong broth.

Von Wolffhügel and Hüppe² have observed the temperature in the

¹ Chem. Centbl., 1884, 639.

² Mittheilungen des kaiserlichen Gesundheitsamts, I, and Abst. in Jahresber. Tier. Chem., II, 1881, 441.

interior of cooking meat and found it always considerably lower than the outer temperature. In a piece of meat weighing 4.5 kilograms the interior temperature after four hours' boiling was only 88° C. The inner temperature of meat which was being roasted varied from 70 to 95° C., according to the size of the piece.

When canned meat in large and even in small cans was kept in a salt-water bath at 102 to 109° C., the interior temperature of the meat rose only to 72 to 98° C., according to the size of the cans. This explains why large cans of meat always have more bad spots than smaller ones. The heat is not sufficient in the large cans to destroy the bacteria or other organisms that cause the meat to decompose. It may be that the formation of an insoluble layer of albumen prevents the penetration of both the boiling water and the heat.

Meat broth.—The quantities of ingredients in meat broth are illustrated by an experiment. We boiled 500 grams of beef and 189 grams of veal bones in the ordinary (German) household way, and obtained a little more than half a liter (543 cubic centimeters) of strong broth or soup. This contained by weight:

	Per cent.
Water	95.18
Total dry substance	4.82
Nitrogen	.19
Protein (N. $\times$ 6.25)	1.19
Fat	1.48
Extractives (carbohydrates, etc.)	1.83
Ash	.32
Potash	.15
Phosphoric acid	.09

Good broths may also be made from less meat and more water, by adding savory herbs to improve the flavors. A. Payen¹ gives the following figures for the materials used in making broths and the composition of the broths as actually prepared from them:

A.—*Materials used for making meat broths.*

	Meat.	Bones.	Salt.	Vegetables and spices.	Water.
	Grams.	Grams.	Grams.	Grams.	Grams.
No. 1	500	.....	.....	.....	1,500
No. 2	1,433.5	430	40.5	.....	5,000
No. 3	500	.....	8	32.2	2,000

B.—*Percentage composition of meat broths prepared from above.*

	Water.	Total dry residue.	Organic substance.	Salt.
	Per cent.	Per cent.	Per cent.	Per cent.
No. 1	98.41	1.59	1.27	0.32
No. 2	97.21	2.79	1.68	1.11
No. 3	97.95	2.05	1.25	.80

¹ *Substances Alimentaires*, 1865, 94–105.

It appears from these analyses that the amount of solids in meat broths is generally small. Consequently their strong taste and stimulating effect upon the nervous system must be ascribed to the meat bases, creatin, carnin, etc., and potassium salts.

A bowl of nourishing soup or bouillon made in the ordinary way—from 3 to 4 grams of meat extract with the addition of spices, egg, salt, etc.—contains only 4 grams of solids. Of these, 3.4 grams is organic matter, 0.34 gram nitrogen, and 0.8 gram is salts having about 0.3 gram of potash.

Besides meat bases, soups contain also more or less gelatin, varying directly with the quantity of bones used in the making. From the composition of bones such as occur in ordinary meat it may be estimated that 100 grams would yield by ordinary kitchen boiling:

	Grams.
Total dry substance	2.0 to 7.5
Nitrogenous matter	0.2 to 2.8
Fat	0.6 to 5.5
Other organic matter	0.1 to 0.5
Salts	0.1 to 0.2

After the meat has been boiled to make broth it still contains meat fiber, part of the albumen, connective tissue, and fat, and if not completely extracted, small residue of meat bases also. Boiling disintegrates the fibers. This is the reason why boiled meat can be more easily chewed and is preferred to raw meat.

Boiled meat.—Of course boiled meat has not the same nutritive value as fresh raw meat. Aside from the fact that meat may be rendered less digestible by boiling, it also loses nutritive material. Dogs have died when fed upon meat which has been extracted by boiling. As it is chiefly the withdrawal of salt which makes the extracted meat an incomplete food, the restoring of the salts will increase its nutritive value and lessen its injurious effects. Meat which has been long boiled should not be used as exclusive diet without at least the soup which it has served to make. It should be remembered, however, that when the meat is put into boiling water at the outset, especially if it is in large pieces, it loses comparatively little nutritive material.

Roasting, frying or broiling is a decidedly more rational way of cooking meat, since the juices are mostly, if not entirely, saved and the tissue and fiber are at the same time loosened by the heat, or by the steam and the fat vapors which the heat generates. In roasting and frying meat a crust is formed on the outside by the coagulating and hardening of the albuminoids. It is supposed that at the same time trifling quantities of carbon and nitrogen are driven off and a small amount of acetic acid is produced which dissolves some of the ingredients of the meat. The fat undergoes a partial decomposition into fatty acids and glycerin, and a little of it is volatilized.

The following analyses, made in König's laboratory, show the comparative composition of specimens of fresh meats, boiled and roasted.

Comparative composition of meats before and after cooking.

	Water.	Nitrogenous matter.	Fat.	Extractive matter.	Salts.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Beef:					
Before cooking (raw).....	70.88	22.51	4.52	0.86	1.23
Same after boiling.....	56.82	34.13	7.50	.40	1.15
Same after broiling (as beefsteak).....	55.39	34.23	8.21	.72	1.45
Veal cutlets:					
Before roasting (raw).....	71.55	20.24	6.38	.68	1.15
Same after roasting	57.59	29	11.95	.03	1.43

The water decreased by roasting and boiling from about 71 to 57 per cent. But such analyses as these permit of no accurate conclusions as to the other changes and losses by roasting. One trouble with them is the difficulty in obtaining perfectly homogenous pieces of meat with the same proportions of fat for the comparative tests. Furthermore, raw prepared meat dishes can not be compared exactly in composition with the same meats after they have been roasted or boiled or fried, because the fat added in the ordinary cooking of beefsteak, cutlets, or roasts alters the composition of the cooked product. On the other hand, cooking without fat would be abnormal, since precisely this addition of fat hinders the decomposing and volatilizing of other constituents of the meat. These considerations should be taken into account in comparing the figures of the table herewith in which the figures of the preceding table are recalculated to the basis of dry matter; that is to say, the water is taken out and the composition of the water-free substance is shown in each case.

Comparative composition of water-free substance of meats before and after cooking.

	Nitrogen.	Nitrogenous matter.	Fat.	Extractive matter.	Salts.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Beef:					
Before cooking.....	12.37	77.31	15.47	2.98	4.24
After boiling.....	12.65	79.06	17.38	.90	2.66
After roasting	12.27	76.73	18.41	1.59	3.27
Veal cutlets:					
Before cooking.....	11.39	71.17	22.45	2.32	4.06
After roasting.....	10.93	68.36	28.18	.09	3.37

These figures show, notwithstanding the objections just mentioned, that in roasting, as in boiling, some extractive matter and some salts are removed from the meat. The reason is that in the roasting, as everyone knows, a small part of the juice oozes out. To take the latter as gravy with the roast is, therefore, entirely rational.

Boiling of bones.—When bones are boiled more or less of their nitrogenous cartilage (ossein) is converted into soluble gelatin. If the boiling is done under high pressure nearly all cartilage is removed from the bones, and after certain manipulations comes into commerce in thin, brittle, colorless tablets. This pure gelatin is used for making jellies, puddings, etc. Glue is impure gelatin. Soft and spongy bones yield most gelatin. Large, hollow ones are broken into small pieces before extraction.

Boiling of milk.—The object of this is to kill the bacteria in the milk and thus for a time prevent its souring. In the boiling a film forms on its surface, which consists of casein, and the peculiar odor given off is due to sulphureted hydrogen.¹ Apparently no other important changes in composition take place; but E. Jessen² finds, nevertheless, that boiled milk is less rapidly digested than raw milk.

Boiling and baking of vegetables.—Vegetable foods are more difficult to digest than animal foods. Their preparation is therefore more com-

plicated and thorough. The nutritive substances are inclosed in cells, often with thick walls, and are not readily acted upon by the digestive fluids. But when vegetables are boiled the cell contents expand and burst through the walls. The fragrant and savory substances are set free with the other materials which have been inclosed in the cells, and their astringency and bitterness are tempered. Some of the constituents are dissolved by the water or suffer other change. Starch, an important ingredient of many

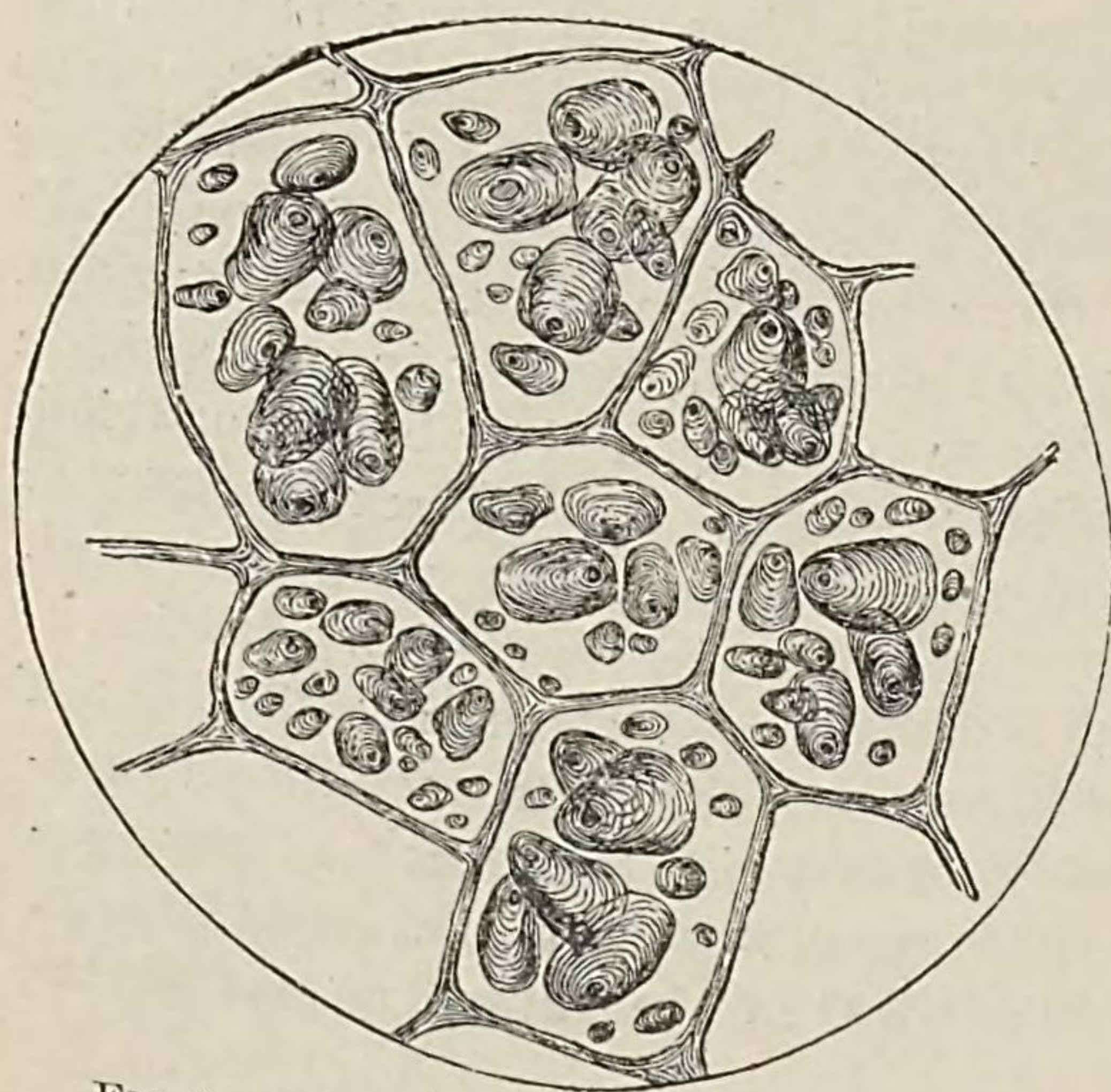


FIG. 2.—Cells of a raw potato, with starch grains in natural condition.

vegetable foods, such as potatoes, wheat, rice, and oat meal, takes up water and assumes the soft, pasty condition which is necessary for its transformation into soluble dextrin and sugar. The boiling of foods, especially vegetables, may therefore be called a preparatory digestive process.

The accompanying diagrams³ (figs. 2, 3, and 4) illustrate the differences in the structure of the starch grains of the potato. No. 1 shows the cell in the raw state. In No. 2 the potato had been boiled a half hour. The starch granules are swollen, but not enough to entirely fill the cells. In No. 3 the potato had been well steamed and then mashed; the cells are filled to distention and a number have burst open so that the starch, now an entirely amorphous mass, is considerably scattered.

Cells from other plants behave like those of the starch-bearing tubers of the potato. The seeds of legumes, such as beans, peas, and

¹ Schreiner, Amtl. Bericht. d. 50. Versammlung deutscher Naturforscher und Aerzte, München, 1877, 218. Abst., Jahresber. agr. Chem., 20, 1877, 422-423.

² See above, p. 75.

³ Märcker, Studien in der Spiritusfabrication.

lentils, are, in their natural state, difficult to digest, because their starch granules lie closely packed within the indigestible cell walls. On boiling the starch swells, the cells burst open, their contents are changed into a pulpy mass which, when strained through a fine sieve, makes a very nutritious and digestible dish. The predominant constituent of the nitrogenous matter "legumin" is dissolved and made more digestible by the phosphate present; but it forms an insoluble compound with lime; hence these vegetables can not be boiled advantageously with hard water.

Flour and starch in their ordinary dry state are hardly fit for food for man. Cooking with

milk or water softens and gelatinizes them sufficiently for making puddings, cakes, omelets, pies, macaroni, etc., but for cakes or bread

a porous light dough is obtained by particular treatment with yeast or baking powder, as will be explained beyond.

By the baking and roasting of starchy foods some starch is also converted into more assimilable dextrin, as in the hard, brown crust of bread, the surface of toasted bread, baked potatoes, and macaroni.

Soups and soup making.—The following tables illustrate the composition and nutritive values of some home-made soups. The

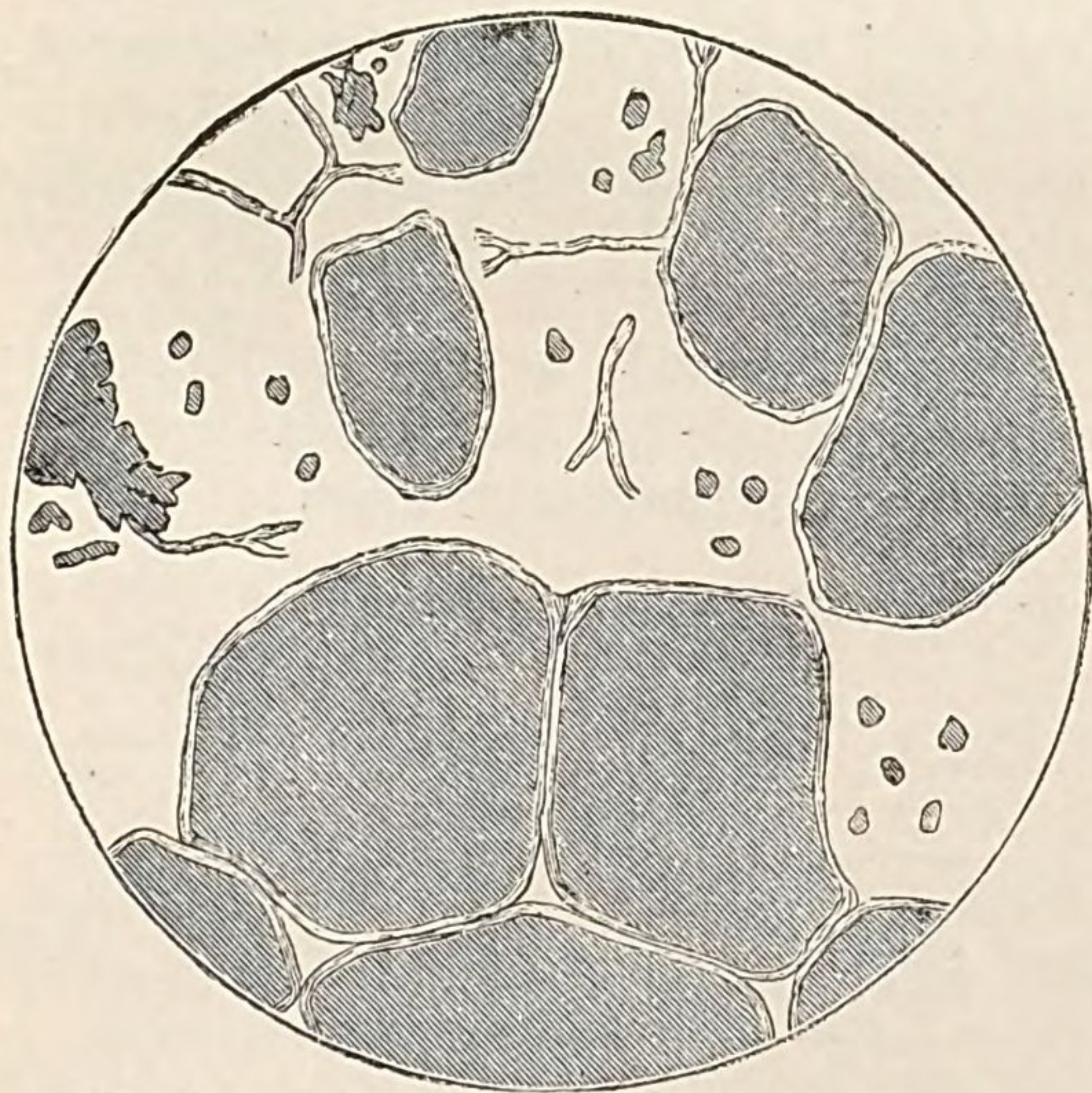


FIG. 4.—Cells of a potato well steamed and mashed.

data are from experiments in König's laboratory. The soups were made in accordance with the methods practiced in ordinary (German) households, to wit: Pea soup, by boiling peas with smoked sausage and

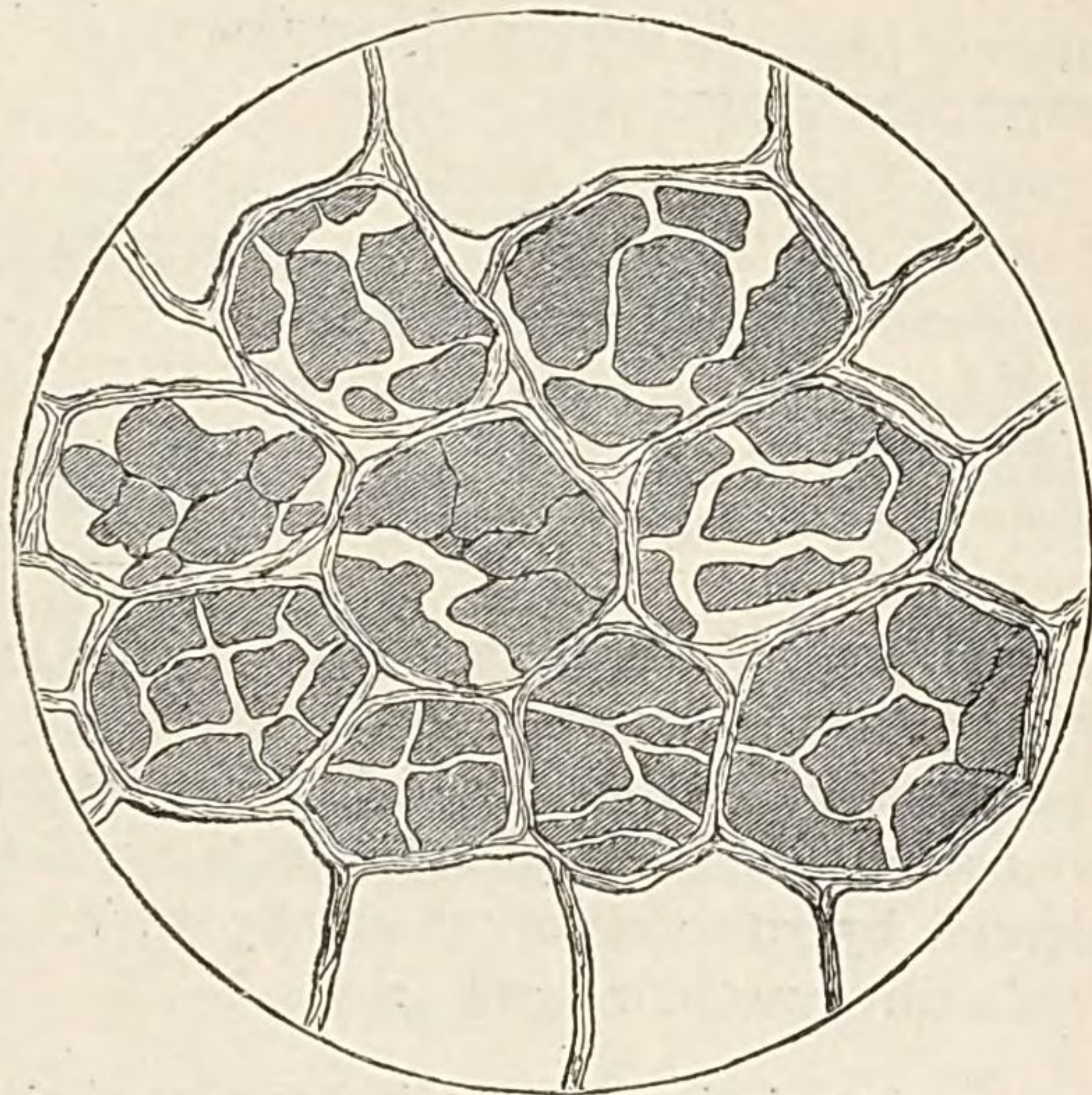


FIG. 3.—Cells of a potato boiled in water one-half hour.

straining off the pulp; potato soup, by boiling potatoes with waste pork; bread soup, from pieces of bread, sugar, and water; farina soup, from barley farina and milk.

Composition of soups (as made in German households).

	Specific gravity.	Water.	Nitrogenous matter.	Fat.	Extractive matter (carbohydrates, etc.).	Cellulose.	Ash.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Pea soup	1.0540	88.26	3.38	0.93	5.60	0.70	1.13
Potato soup	1.0385	90.96	1.37	1.55	4.87	.26	.99
Bread soup	1.0455	88.81	1.25	0.16	8.92	.38	.48
Farina soup	1.0415	87.66	2.44	1.48	7.46	.09	.87

Evidently these figures can have no general value, as the composition of soups must vary with the materials used and the methods of preparation, neither of which are ever uniform.

Loss of nutritive substance in the boiling of vegetables.—This is illustrated by some observations by P. Wagner and K. Schaefer.¹ The following are their figures:

Loss of mineral matters in the boiling of potatoes with and without skins.

	The boiling water poured off from 1 kilogram of potatoes contained—			Lost from original amount in the potatoes.		
	Total mineral matter.	Potash.	Phosphoric acid.	Total mineral matter.	Potash.	Phosphoric acid.
Unpeeled potatoes:	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Boiled	0.28	0.10	0.02	3.64	3.32	1.12
Steamed	.09	.03	.005	1.17	.69	.03
Peeled potatoes:						
Boiled	2.15	1.25	.35	28.86	38.33	22.87
Steamed	.55	.26	.07	7.28	6.93	4.57

After the boiling of other vegetables as well as potatoes the excess of water is commonly thrown away. That this may involve considerable waste is shown by the following experimental results:

Ingredients in waste water from 1 kilogram of green vegetables.

	Total solids.	Nitrogenous matters.	Nitrogen-free extractives (carbohydrates, etc.).	Total inorganic matter.	Potash.	Phosphoric acid.
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Spinach	8.578	1.684	3.519	3.375	2.326	0.322
Carrot tops (chopped)	15.252	3.312	5.609	6.331	4.196	.348

The loss varied from 9 to 18 per cent of the total amount of soluble matter in the unboiled vegetable foods.

¹Sächs. landw. Ztg., 1885, 33, p. 369. Abst., Jahresber. agr. Chem., 28, 1885, 443.

BAKING OF BREAD.

In the making of flour from cereal grains the less digestible outer coating is removed by the process of milling, and the more easily and completely digestible material is left in the flour or meal.

The starch grains of the product thus prepared are inclosed in cells, the walls of which, as explained above, make it difficult for the digestive juices in the alimentary canal of man to get at them and prepare them for absorption. We accordingly mix the material with water or milk and heat it. The starch swells, the cells burst open, and a paste or dough is formed, and thus the material is partly prepared for digestion. But in the baking of bread still further steps are taken which result in loosening the mass or making it "light," to use a common phrase, while at the same time the taste is greatly improved.

Flour simply mixed with water and baked is neither as palatable nor as digestible as is to be desired. It is difficult to chew, and the small, impenetrable pieces when swallowed resist the action of the digestive fluids. Hence, in the making of the dough some substance or substances are added to make it "rise"—that is, to generate in it a multitude of small bubbles of gas. Such materials are leaven, yeast, and baking powders. The two former convert some starch of the flour by fermentation into alcohol and carbonic acid; the latter, which usually contain mixtures of suitable chemicals, generate carbonic acid upon contact with the moisture of the dough. In making so-called "aerated bread" carbonic acid ready made is worked into the dough by machinery in closed vessels. When dough thus prepared is put into the hot oven the bubbles of gas which permeate it are expanded and thus make larger cavities. At the same time the minute, hard granules of starch, hitherto unchanged, are by the moist heat softened and gelatinized. The ferments of yeast and leaven are killed by the heat and thus their further action upon the bread is prevented. The outer surface of the bread is more heated than the interior and much of the starch is changed to dextrin, which is more soluble and believed to be more digestible. Hence the crust is often recommended for persons with enfeebled digestion. The same change occurs in the outer, browned surface of pieces of bread when toasted.

EFFECTS OF COOKING AS STATED BY HALLIBURTON.

To the statements of Professor König, above cited, the following summary of the effects of the cooking of food, by Professor Halliburton, of King's College, London, may be added:¹

The cooking of foods is a development of civilization, and much relating to this subject is a matter of education and taste rather than of physiological necessity. Cooking, however, serves many useful ends:

(1) It destroys all parasites and danger of infection. This relates not only to bacterial growths, but also to larger parasites, such as tapeworms and trichina.

(2) In the case of vegetable foods it breaks up the starch grains, bursting the cellulose and allowing the digestive juices to come into contact with the granulose.

¹ The Essentials of Chemical Physiology, p. 34.

(3) In the case of animal foods it converts the insoluble collagen of the universally distributed connective tissues into the soluble gelatin. By thus loosening the binding material, the more important elements of the food, such as muscular fibers, are rendered accessible to the gastric and other juices. Meat before it is cooked is generally kept a certain length of time to allow *rigor mortis* to pass off.

Of the two chief methods of cooking, roasting and boiling, the former is the more economical, as by its means the meat is first surrounded with a coat of coagulated proteid on its exterior, which keeps in the juices to a great extent, letting little else escape but the dripping (fat); whereas in boiling, unless both bouillon and bouilli are used, there is considerable waste. Cooking, especially boiling, renders the proteids more insoluble than they are in the raw state; but this is counterbalanced by the other advantages that cooking possesses.

ATKINSON'S DEFINITION OF COOKING.

The subject is viewed from a somewhat different standpoint in the concise definition by Dr. Edward Atkinson:¹

We may define the art of cooking as consisting in applying heat to each of these subjects in such a way as (1) to render it digestible, so that its nutrient properties may be assimilated in true proportion in the human system; (2) to render it appetizing by the development of its own specific flavor; (3) to combine different kinds of food material in such a way that each will render the other palatable; (4) to remove certain portions which may not be palatable or digestible after the first application of heat, either as waste, like bone, as excess, like much of the fat that may be used for other purposes, or as woody fiber in many vegetables; (5) to add to the essential elements salt in its due proportion in almost every process, and sugar in some combinations, and other condiments, spices, or flavorings in such a way as to develop rather than to disguise the true flavor of the principal food material entering into each dish.

INVESTIGATIONS BY MRS. RICHARDS AND MRS. ABEL.

In 1889 and 1890 a grant was made by the trustees of the Elizabeth Thompson fund for experiments upon cooking. This was supplemented by private gifts for the same purpose. The experiments were carried out by Mrs. Ellen H. Richards and Mrs. Mary H. Abel. They included some trials with the Aladdin oven, the invention of Dr. Edward Atkinson, through whose instrumentality the investigations were undertaken. The following statements are from the reports of Mrs. Richards and of Mrs. Abel to the trustees of the Elizabeth Thompson fund. They are taken from a paper by Dr. Atkinson on "The right application of heat to the conversion of food material," read at the meeting of the American Association for the Advancement of Science, in Indianapolis in August, 1890:

The investigation of certain scientific principles of hygienic and economic cookery, in aid of which a grant of \$300 was made from the Elizabeth Thompson fund, was to cover four points:

(1) The determination of the time and temperature required for the best results in flavor and digestibility of the several classes of food materials, i. e., meat, vegetables, etc.

¹ Suggestions Regarding the Cooking of Food, published by the U. S. Department of Agriculture, 1894.

(2) To ascertain the difference, if any existed, in the chemical character of bread quickly baked and that baked for a long time.

(3) To endeavor to secure a simple and effective measure of oven heats.

(4) To modify the ovens in common use in order to obtain more digestible food and to secure more economical use of food materials.

The study of these points was made by Mrs. Mary Hinman Abel in connection with the work of the New England Kitchen, thus securing more than mere laboratory results. The analyses were made in the laboratory of sanitary chemistry of the Massachusetts Institute of Technology by Messrs. G. L. Heath, F. S. Hollis, W. R. Whitney, and Misses Bragg, Day, Sherman, and White. The apparatus is being used constantly in further experiments.

The accompanying report gives in detail the results of the six months' work. It may be briefly summarized as follows:

(1) Two standard dishes have been perfected which have stood the test of six months' daily sale with constantly increasing popularity. The time and temperature necessary for these dishes are known, as well as the exact proportions of the necessary ingredients. Meat and vegetables are represented. The two dishes are beef broth for invalids, and pea soup. From the beef broth other soups are made.

(2) The change in the composition of bread when baked a long time at a moderate temperature has been demonstrated.

(3) The question of an oven thermometer has not been satisfactorily settled.

(4) In regard to the American cook stove we have come to the conclusion that no general improvement in the character of prepared food can be expected with so crude and unreliable a means. As we have demonstrated that for most substances a long time and a moderate heat is required for the best results, we must find an apparatus to secure this. Nothing which we have seen or heard of quite meets the ideal requirement.

In our practical experiments we have confined ourselves to the effect of a moderate degree of heat, continued for a considerable time. We have not considered to any extent the methods of broiling or so-called roasting, because it is well known that only tender, high-priced cuts of meat can be thus made fit for the table.

ESSENTIALS FOR GOOD COOKING APPARATUS.

For ordinary cooking apparatus the following are essential points:

(1) The degree of heat should be under perfect control, increased, diminished, or withdrawn at will, and without loss of time. This can only be perfectly attained with liquid or gaseous fuel. Solid fuel demands constant and equable running, and gives best results in large masses. The small fire box of a cook stove, and the urging of the fire for a short time three times a day are fatal objections to the use of anthracite.

(2) A tightly closed vessel heated by steam, or hot water, or hot air, offers many advantages over the top of a red-hot stove or the inside of a nearly red-hot cast-iron oven for cooking, except for the broiling and the roasting of meat and for some other methods of cookery which require the quick application of heat.

(3) For all purposes of slow cooking the oven should have a non-conducting covering which retains the heat where it is wanted, and also allows of tight closing and of security from the constant watching required by the fitful heat of a stove.

This use of a close oven with a non-evaporative atmosphere, seems to be the secret of the retention of the delicate and volatile flavors which usually flavor the house and street, and not the food as it is brought to the table.

Three kinds of apparatus are now in the market which meet more or less of these requirements, and all may be used with a kerosene lamp. The Arnold steam cooker uses steam generated in a sort of flat boiler. For some purposes, such as the cooking of cereals, as mush, and also for the preparation of a few quarts of soup, and for the slow cooking of meat in its own juices, we find this cooker very effective. The liability to leakage and the difficulty of mending are drawbacks, and there is no non-conducting covering.

The Wanzer cooker we have not been able to purchase, as it is held by an English patent. It has a special lamp of some merit and it has good points, as the demonstration which the patentees gave us showed. The loss of heat is, however, very large and the lamp will run only four hours.

The Aladdin oven or covered stove. This is a square or oblong box of sheet iron of any desired size, with a non-conducting covering of magnesian cement or wood pulp, and is heated with a kerosene lamp or gas burner. The size in use for these experiments is 18 by 12 by 14 inches, and gives a cooking space at least equal to that of a No. 8 Crawford cook stove, and when empty can be heated to about 300° F. in an hour, and maintain that temperature for 8 hours by a single kerosene lamp of the Rochester-burner type, with the consumption of 1 quart of kerosene. When well filled with food materials in small portions the heat is sufficient to heat them in about twice the time allowed by an ordinary cook stove. When the space is completely filled with a vessel containing, for instance, 40 pounds of meat and bone and 15 quarts of water, the whole is raised from a temperature of 70 to 180° F. in 7 hours, and to 212° in 12 hours. If the lamp is then taken away or allowed to go out the temperature does not fall below 190° for 4 hours.

For this 12 hours, 1½ quarts of kerosene are needed, or a gas burner can be used. For simplicity, effective use of heat, economy of fuel, and development of flavor in the food cooked, combined with increase of its digestibility, the Aladdin oven is an apparatus far exceeding in merit any other now in market. It will not meet all the demands that the modern cook now makes of the kitchen stove, and it may be in several respects improved, but in the application of well-known and long-tried scientific principles to the cookery of food, it is a distinct advance and a most valuable invention. * * *

COOKERY OF MEAT.

The ideal preparation of a food for human use requires that the nutriment it contains should be utilized to the fullest extent, and this implies not only that it shall be in such a state that the digestive juices can best act on it, but that these digestive juices shall be properly stimulated to do their work by the taste or flavor of the food. Therefore in the cooking of meat we undertook to answer this question: What method can be employed that will yield the most in nutrition and flavor? It was determined to experiment first with beef of the cheapest cuts, as the neck and shin, these cuts although tough being among the richest in nutriment as shown by analysis, and to utilize this nutriment in the form of broth or as a basis for soups.

In examining a shin of beef we find it to consist, as far as our uses are concerned, of, first, muscular fiber; second, connective tissue; third, bone. We have here three distinct food materials, which if treated separately would require quite different processes.

(1) Muscle fiber. To prepare this for the digestive juices requires only that slight application of heat that develops the flavor which is most agreeable to the civilized palate, and so increases the nutritive value of cooked muscle fiber over raw, at least for the civilized stomach. A familiar example of the most perfect method of cooking the muscle fiber alone is broiling.

(2) The connective tissue and tendons. We find these intimately connected with the muscle fiber, and their food material is finally obtained mostly in the form of gelatin. To render these substances available for food they must be first hydrated, and then to a greater or less extent dissolved. The length and difficulty of this process differs with the age of the animal, its food, and also on the length of time the meat has been kept after killing, all of which affects the toughness of the enveloping membrane. The connective tissue in a sirloin steak is so tender that the heat necessary to cook the muscle fiber, as in broiling, is sufficient also to hydrate the connective tissue by merely heating the water contained in the steak; that of the tougher cuts, like that of the shin, need a much longer application of heat.

(3) The bones also contain a substance which yields gelatin, and to extract it

requires a long application of heat. It became evident at this step in the investigation that since muscle fiber, connective tissue, and bone must be cooked by the same process, and that this process must be a long one in order to affect the necessary changes in the connective tissue and the bone, some means must be devised to prevent the overcooking of the muscle fiber from dissipating its flavor. This settled the first requirement of the cooking vessel to be used, namely, that it must be tightly closed. On this account the ordinary iron pot was rejected, but the long famous Papin soup digester with its tightly screwed top was given a good trial on the kitchen range. But other requirements were to be met. The perfect hydration of the gelatin yielding connective tissue of meat and the proper cooking of the albumen would require that the temperature be perfectly under control. It was found to be impossible to regulate the temperature inside the digester; for, added to the ordinary difficulty found in using the variable kitchen range, was the fact that the tightly closed digester gave no sign of the rising temperature till the mischief was done. Placed over the more easily regulated flame of gas or kerosene so large a vessel showed great unevenness in the temperature in the top and bottom, and both of these methods were expensive as to fuel.

We next tried cooking the meat in earthen jars placed in the Aladdin oven to which the heat of a kerosene lamp was applied, and the results obtained were so good that it became evident that we were on the right track. The meat and bone placed in a jar and covered with cold water rose slowly and steadily, without any attention on the part of the cook, to a required temperature and could be held there for any length of time by simply lowering the flame of the lamp. The non-conducting shell of the oven assured nearly the same heat to the bottom, top, and sides of the cooking vessel, and did the work with a minimum amount of fuel.

We had aimed to produce a food that should hold nitrogen compounds in solution with all the flavor available. This would require that the extraction of the food material from the meat should be effected as nearly as possible before that temperature was reached at which the flavor once developed would be dissipated by the escaping steam. It was found by later experiment that the agreeable flavors peculiar to boiling soup were not brought out till the boiling point was nearly reached. This by our present method is 12 hours after the beginning of the cooking, and near the end of the process, so that the least possible quantity of these flavoring substances is lost by further cooking.

We, therefore, had a tin-lined copper vessel holding 30 quarts made to fit the oven, thus utilizing the entire inside space. Three of them have been in constant use in the kitchen since our early experiments demonstrated their value. By this method only have we been able to meet our requirements for the proper cooking of meat of the tougher cuts, and at the same time extract from bone and tendon a due amount of gelatin. We consider it quite probable that a steam apparatus might be devised that would do the work on exactly the same principle by surrounding the cooker with a heated medium easily regulated and using low pressure; the steam jacket of the restaurant does not answer the requirements, but to have something of this kind constructed did not come within our means.

Whether the Aladdin oven is the ultimate best form of a cooker we do not attempt to say, but it certainly deserves a high place because constructed on the principle of holding the heat to its work by a non-conducting covering, and for using an easily regulated fuel. Other contrivances examined by us, however convenient and ingenious, are on the old lines and show no distinct advance toward an application of scientific principles to cooking methods.

The method employed in the Aladdin oven is the same whether the meat and bone are cooked with a small quantity of water and used in the form of a stew, or with a larger quantity of water, the meat at the end of the process being pressed dry of its juices. This latter method is the one most employed at the kitchen because of our large consumption of this broth, merely salted as beef broth for invalids, and as a basis for our various soups.

COMPOSITION OF BEEF JUICE, BEEF TEA, ETC.

In view of the unexpected demand for the broth for the sick room we were obliged to study the composition of the various preparations in use and the possibilities of the yield of meat under various kinds of treatment.

Beef juice obtained from the best steak which has been merely warmed through over the coals and then entirely deprived of soluble substance by a screw press, is undoubtedly the most concentrated of the liquid foods. If prepared with the most scrupulous care, from the best material, and used at once, it probably leaves nothing to be desired. But in unskilled hands the risks are considerable in using this raw and most easily putrescible material. It is also a slow, laborious, and expensive operation.

Beef tea, as ordinarily made, is of uncertain composition; it may be only the juice of the meat set free by the coagulation and shrinking of the fiber on heating. Such is the beef extract made by heating chopped steak in a bottle. It may be an aqueous infusion of very variable strength, containing chiefly phosphates, kreatin, and certain extractive matters, agreeable to the palate, but of little nutritive value. It occurred to us to prepare on a large scale a broth of constant composition from both meat and bone, in such a manner as to secure a nutritive value at least equal to that of milk (without its fat), and without sacrificing the appetizing flavor. The bone gives a proportion of gelatin which, when flavored with the meat extract, is believed to be of high nutritive value.

The following table gives a comparison of these different preparations:

	Meat.	Total solids.	Solids, juice filtered before coagulation.	Solids, juice filtered after coagulation.	Coagulable albumen.	Extract of meat.	Salts or ash.
Beef juice from meat slightly broiled and pressed (round).....	<i>Per cent.</i> 26.8	11.9	10.8	4.93	6.97	<i>Per cent.</i> 3.90	.....
Beef juice from meat slightly broiled and pressed (neck).....	21.9	9.9	9.4	4.72	5.18	3.56	1.36
Beef tea, chopped beef heated in a bottle without water.....	26.4	7.91	.....	5.72	2.19	2.09	.....
Beef tea, New England Hospital, with water.....		3.23	.....	2.55	.68	.....	.....
Beef tea, with equal weight of water 2 hours at 75° C., then boiled 2 hours.....			.....			2.15	.....
Beef tea with twice its weight of water 2 hours at 70° C., then 2 hours at 85° C.....			.....			2.62	.....
Beef broth, New England kitchen, average of 26 analyses.....		3.53	.....			4.40	.....

It will be seen that the yield of lean beef to water is only about 2 per cent, that is to say, from 3 pounds of juicy steak only about 1 ounce of solid matter is obtained. The broth of the kitchen adds to this 2 per cent from the meat, 2 per cent of gelatin from the bones.

HOW LONG BROTH MAY BE KEPT.

We have taken some pains to determine how long this broth will keep under different conditions, an investigation in the field of household bacteriology. We have settled for our own practice the great importance of: (1) Sterilizing with boiling water every utensil used in the process. (2) Rapid cooling of the broth as soon as made, to below the temperature most favorable to the growth of bacteria. (3) Keeping the broth at as low temperature as possible.

As a result of several experiments during the hot days of July, it was found that broth which spoiled in 12 hours in a cellar where the thermometer stood at 70° F. kept sweet for 7 days if placed while still hot in small jars in an ice chest at 32° F., the cake of fat on the top remaining undisturbed.

PEA SOUP.

Of our many experiments in the cooking of cereals and vegetables we consider only one complete and satisfactory enough to report upon. The principles here demonstrated can, however, be applied to many different dishes.

On account of the high food value of the legumes and the general impression that as ordinarily prepared they are indigestible we determined to make careful experiments on methods of cooking them. First, we undertook to make what would be a standard soup out of dried split pea. We found that in this case also the principle of long, slow cooking was the secret of success. * * * It was found that not until the split pea was cooked 4 or 5 hours, was the result that thick *purée* of rich and mellow flavor that has been so popular in the New England kitchen.

SUGGESTIONS AS TO INVESTIGATIONS NEEDED.

A common remark made by those who have studied the conditions of living of people of moderate incomes and the poor in the different parts of our country is that one of the things most needed for the improvement of the home life of people of these classes is an improvement in their cooking. To replace dear food badly cooked by economical food well cooked is important for purse and health. To make the table more attractive will be an efficient means for making home life more enjoyable and keeping the father and sons from the saloon.

Those who have had experience in cooking schools have come to realize the need of better understanding of the principles which underlie the right preparation of food. The ordinary kitchen stove and the receipt book do not meet the demand, and nothing short of accurate research can meet it.

"The coming fad is domestic science." Indeed that fad is not coming but is already here. The danger is that it may go as a fad and leave no permanently useful impression. But it may be made, instead of a fad, a most salutary educational movement. There is good ground to hope that it will prove so, but only on one condition, namely, that it be based upon thorough scientific knowledge. Such knowledge must be based upon research, just as accurate and just as thorough as that which is given to the study of the other profound problems of chemistry, physics, and hygiene in their application to daily life.

The time is ripe for this inquiry. The leaders in physical, hygienic, and economic science have learned that such subjects are worthy of their attention. The higher institutions of education and research are finding that such inquiry and the teachings that go with them are a part of their truest function. Among the men and women connected with the cooking schools, the experiment stations, the agricultural and mechanical colleges, and other institutions for technical training, the medical schools, and the chemical, physical, and biological laboratories of the universities, there are not a few who are capable of carrying on such inquiries, and with most excellent results.

The general character of the investigations now needed is illustrated by what was said above regarding the digestibility of food and the effects of cooking. More specific suggestions will be best made when the work is ready to be done.

EFFECTS OF COOKING ON DIGESTION.

One of the most important practical topics now demanding investigation is the effect of cooking upon the digestibility and nutritive value of food materials. The general lines of inquiry needed were referred to in connection with the description of experiments above. Some such plans for details as the following are at least worthy of consideration:

Suppose the question to be the effect of the frying of meat upon its digestibility, and that the investigator has at his disposal a subject, a healthy man for instance, who has been trained for the investigation and who is able to attend to some of the mechanical and less agreeable details. A piece of lean beefsteak of proper size could be divided in six parts of like weight and composition and set aside in a refrigerator. Portions representing the whole could be analyzed. The six portions could be eaten, each with given amounts of starch and other carbohydrate materials, and with butter and other substances which would furnish the fats. A ration could be provided which would be fit for sustenance and at the same time would not contain any considerable quantity of material which would interfere with the determination of the actual digestibility of the meat, especially its protein. Three of the portions could be used, during a period of 3 days, nearly raw. The experiment of this period would thus show the digestibility of the meat under the most favorable circumstances; in other words, what might be called its intrinsic digestibility by the subject with whom the experiment was made. The remaining three portions could be fried until well done or overdone, and eaten during a second period of 3 days in the same manner as before. The experiment in this period would show the digestibility of the meat when thus fried. Comparison of the results obtained in the two periods would show the effect of the frying upon the quantity of the meat digested. It must be borne in mind, however, that one series of two comparative experiments would not suffice, but that the investigation should be repeated with the same person and also with different persons. When the experimenter has the method for this kind of work well in hand, it is not extremely laborious, and if conducted for a considerable time will bring results of decided practical value.

This, of course, is only a suggestion for an experiment for testing the effect of one kind of cooking upon one kind of food, but it serves to illustrate how such inquiry may be carried on. Such inquiries are greatly needed, the time is ripe for them, and there are persons who are competent to conduct them. Experience will lead to improvements in methods and indicate the questions which are most desirable for study, and the results will find immediate and widespread application. Here, again, systematic, cooperative work will bring the best results with the least expenditure of time, energy, and money.

CHAPTER VI.

USES OF FOOD IN THE BODY—METABOLISM.¹

The body of the animal and the food which nourishes it are composed of the same elements. The compounds in the body are more or less similar to those in the food. The processes by which the elements are transformed into the compounds in the plant which serve the animal for food are essentially synthetic. Those by which the compounds of the food are transformed into the compounds of the body are partly synthetic and partly analytic. Those by which the compounds of the food and of the body are utilized in the performance of the bodily functions and are finally excreted are mainly analytic. The generalization of Liebig, that the chemical changes in the plant are synthetic and those in the animal analytic is, in the main, true, but there are important exceptions both in the animal and in the plant.

The later development of science has given us clearer ideas not only of the chemical but also of the physical changes that take place in the living organism.

The physical processes in the plant are mainly those of the transformation of kinetic into potential energy; those in the animal are mainly transformations of potential into kinetic energy. The latent energy of the food is changed to heat and muscular power as the food is used in nutrition.

METABOLISM OF MATTER AND ENERGY IN THE BODY.

To these kinds of change the term metabolism is frequently and appropriately applied. The processes of metabolism in the body are of two definite but closely allied kinds—the metabolism of matter and the metabolism of energy. It is commonly assumed that these two processes conform, the one to the law of the conservation of matter and the other to that of the conservation of energy. Exactly this form of statement is not usual. Indeed, I do not recall having met it in print

¹The experimental inquiry upon metabolism has been very active during the last few years, and a reasonably full treatment of the subject within the time allowed for the present bulletin is impracticable. It has seemed best, therefore, to present the following brief statements herewith and leave the more detailed treatment for a subsequent publication.

at all, but the principles thus enunciated have been more or less definitely assumed by writers and experimenters during the last 20 years or more. In the following pages the attempt will be made to distinguish between the chemical and physical changes involved in bodily metabolism, and to explain briefly some of the ways by which the changes are measured, and the use that is made of these measurements in the discovery of the ways in which food performs its functions in nutrition.

The bringing of these complex processes into line with the two fundamental laws of the conservation of matter and the conservation of energy helps greatly toward simplifying the whole subject, clearing up details that have been obscure and placing the doctrine of nutrition upon a rational and simple basis. In the light of these laws many of the results of experimenting are more easily interpreted, imperfections in plan and errors in execution of past experimenting are brought out, and the ways in which the unsolved problems before us may best be studied are laid open. Experimenter, teacher, and student are alike helped by this same coordination of principles. At the same time the theory of nutrition thus becomes plainer to the practical man. He can understand it more easily if it is put in terms of "flesh formers" and "fuel values" than if he must consider protein, fats, and carbohydrates in the ways which have become so generally current.

Food has two chief functions—to build tissue and to serve as fuel. In the building of tissue we have to do with the metabolism of matter. In serving as fuel, to yield heat and muscular power, we have to do with the metabolism of energy. The protein compounds are the tissue formers. The fats and the carbohydrates are the chief fuel ingredients; but protein compounds also serve as fuel. In this service as fuel the nutrients replace each other in proportion to their potential energy. The economy of food in nutrition requires sufficient protein for the formation of tissue and sufficient energy for supplying heat and strength.

The fat of the body is its reserve store of fuel. The fuel value of the fats is more than twice as great, weight for weight, as that of the protein or carbohydrates. Fat is body fuel in its most concentrated form. Therein lies the economy of nature in the storage of fat in the body.

The fat of the food is stored as fat in the body. The protein and carbohydrates of the food are transformed into body fat. The fuel value of the food thus becomes a measure of its capacity for fat formation.

Of course the whole doctrine of nutrition is not as simple a matter as these statements would imply, but they do represent its fundamental principles.

In the metabolism of matter and energy we have the foundation of the theory of nutrition, the starting point of experimental inquiry, and the means of simplifying the theories which we have to teach.

METABOLISM OF MATERIAL—DAILY INCOME AND EXPENDITURE OF THE BODY.

To measure the quantities of material metabolized it is necessary to take into account the total income and outgo of matter. The income of matter consists of food, drink, and oxygen of inhaled air. Part of this material is transformed into blood, muscle, fat, bone, and other tissues. The rest, together with the materials worn out with use, undergo various chemical transformations and are finally given off from the body in the form of gases through the lungs and skin, of liquids and solids excreted by the kidneys and skin, and undigested residue of food and metabolic products excreted by the intestines. The substances excreted in these ways constitute the outgo of material. In accurate experiments upon the income and outgo these materials are measured by their chemical elements. It is assumed that all of the gain or loss of nitrogen represents the food and body protein. It is customary to take the quantity of nitrogen multiplied by the factor 6.25 as the measure of this protein. It is also assumed that all of the nitrogen of the income is that of the protein of the food; that all of the nitrogen of the outgo is contained in the nitrogen excreted by the kidneys and intestines. The difference between the nitrogen taken in and that excreted is the measure of the gain or loss of body nitrogen. If there be less nitrogen excreted than was contained in the food, this nitrogen has been stored in the body. Assuming that all has been stored as protein, we have simply to multiply the quantity by the factor 6.25 and we have the quantity of protein stored in the body. In like manner, if there be loss of nitrogen, this quantity multiplied by the same factor gives the loss of protein from the body during the same experiment.

The protein contains besides nitrogen certain quantities of carbon, oxygen, and hydrogen. The assumed average composition of protein will give the quantities of these elements stored in the body as protein or lost in that form. The nitrogen of income and outgo is thus used as the measure of the gain or loss of body protein and also of the gain or loss of carbon, oxygen, and hydrogen in that body protein.

For determining the gain or loss of protein, we next consider the gain or loss of fat. This is comparatively simple, if we assume that there is no gain or loss of carbohydrates. In this case we have need only to use the figures for gain or loss of carbon. Part of the carbon goes with the nitrogen of the protein. If, after this has been calculated out, there remains a loss of carbon, the inference is that the body has lost fat, and as the composition of the fat in the body is practically constant, it is very easy to calculate from the loss of carbon the quantity of fat which the body has lost. In like manner, if the income of carbon is more than the outgo the inference is that carbon has been stored as fat and the quantity of fat thus stored is easily calculated.

In what was just said it was assumed that the quantity of carbohydrates in the body remains constant. To determine whether this is actually so or not, the exact gain or loss of hydrogen and oxygen, as well as of carbon, should be known. Unfortunately experimental inquiry has not yet attained to the degree of perfection which makes it possible to determine the hydrogen and oxygen with the desired accuracy. The determinations of income and outgo of nitrogen are made very easily, since practically all of the nitrogen involved, with the exception of the extremely small amount excreted by the lungs and skin, is given off by the kidneys and intestines and can be determined with great accuracy. The quantity excreted by the intestines is a nearly accurate measure of the quantity digested, the only disturbing factor here being found in the metabolic products. The quantity excreted by the kidneys gives an approximately accurate measure of the total quantity metabolized. The determination of gain or loss of protein is, therefore, a comparatively simple matter, and experiments in which these determinations are made are very common.

The larger part of the carbon of the outgo is excreted in the respiratory products. To determine its amount it becomes necessary to measure and analyze the respiratory products. This is accomplished by means of the respiration apparatus. Various forms of respiration apparatus have been devised. The most successful is that of Pettenkofer, which has been somewhat modified by Voit. With this, carbon of inhaled and exhaled air can be determined with quite satisfactory accuracy. The determinations of hydrogen have been less successful. The materials determined have been carbon dioxide and water. In late experiments at M $\ddot{o}$ ckern and G $\ddot{o}$ ttingen with domestic animals the hydrocarbons have also been determined.

The tabular statement herewith will serve to indicate succinctly the ways in which the chemical and physical changes take place in the body, in so far as they are now understood, and to compare them with the changes that take place in the calorimetric apparatus which is used for the experimental study of the subject. It should be borne in mind, however, that portions of the food are being constantly stored in the body and becoming parts of its tissues and organs, while previously stored material is at the same time being consumed. The materials stored and consumed may, like those of the food, be grouped as protein, fats, carbohydrates, and mineral matters.

Transformation of material and energy in calorimeter and in animal body.

A.—METABOLISM OF MATTER.

Compounds in food.	Chemical products into which the compounds are transformed by—		
	Direct oxidation in calorimeter.	Cleavage and ultimate oxidation in body.	
Fats, carbohydrates, alcohol, organic acids, etc.	$\left\{ \begin{array}{l} \text{C all to CO}_2 \dots\dots\dots \\ \text{H all to H}_2\text{O} \dots\dots\dots \\ \text{O forms CO}_2 \text{ and H}_2\text{O} \end{array} \right.$	$\left\{ \begin{array}{l} \text{C appears as CO}_2 \dots\dots\dots \\ \text{H appears as H}_2\text{O} \dots\dots\dots \\ \text{O appears as CO}_2 \text{ and H}_2\text{O} \end{array} \right.$	Of respiratory products.
Proteids, amides, etc.	$\left\{ \begin{array}{l} \text{C all to CO}_2 \dots\dots\dots \\ \text{H all to H}_2\text{O} \dots\dots\dots \\ \text{S all to [H}_2\text{] SO}_4 \dots\dots\dots \\ \text{P all to [H}_3\text{] PO}_4 \dots\dots\dots \\ \text{N becomes free N?} \\ \text{O forms compounds as above.} \end{array} \right.$	$\left\{ \begin{array}{l} \text{C appears as CO}_2 \dots\dots\dots \\ \text{H appears as H}_2\text{O} \dots\dots\dots \\ \text{S appears as SO}_4^1 \dots\dots\dots \\ \text{P appears as PO}_4 \dots\dots\dots \\ \text{N appears as urea, etc.} \end{array} \right.$	Of respiratory products. Excreted by kidneys and skin.
Creatin and allied compounds.	$\left\{ \begin{array}{l} \text{C} \\ \text{H} \\ \text{N} \\ \text{O} \end{array} \right.$ As above	Not metabolized. (?)	

¹In combination with bases, metallic or organic.

B.—METABOLISM OF ENERGY.

The potential energy of the compounds of the food is transformed by—		
Direct oxidation in calorimeter—	Cleavage and ultimate oxidation in body—	
Completely into heat.	$\left\{ \begin{array}{l} \text{Mostly into—} \\ \text{1. Heat} \dots\dots\dots \\ \text{2. Muscular power} \dots\dots\dots \\ \text{3. Intellectual and nervous energy. (?)} \end{array} \right.$	But part remains untransformed in the partially oxidized or unoxidized compounds given off from: 1. The lungs and skin in respiration, viz (very minute quantities of): Hydrocarbons and other volatile compounds. 2. The kidneys (and to very slight extent from the skin), viz: Urea, uric acid, creatinin, or other compounds. 3. The intestine, viz: Undigested residues, and cleavage products of food, and metabolic products, from digestive juices, etc.

In ordinary experimenting the metabolism of mineral matters is not taken especially into consideration, as the quantities of mineral matter and energy metabolized are extremely small.

The total quantity of carbohydrates in the body tissues is also small, and is, like that of the mineral matters, assumed to be very nearly constant. Hence the metabolism of the carbohydrates belonging to the body is ignored in ordinary experiments upon the income and outgo

of the body. For accurate results, however, it is essential to determine whether the body loses or gains carbohydrates.

The protein and fats of the body are constantly increasing or decreasing; in other words, the metabolism of body protein and body fat has to be accurately measured and taken into the account in the balancing of the incoming and outgoing of material. The total transformation of energy in the body includes that of body material as well as that of food. It is assumed that the potential energy of body protein and body fat is the same as that of protein and fat of the food. No way has yet been devised for measuring the exact quantities of body protein and body fat metabolized in a given time. What experiments on income and outgo of material do show is the total gain or loss of material in the body. That is to say, if the body during an experiment of 24 hours contains a gram more of fat than at the beginning, the inference is that whatever may have been the quantity of body fat metabolized the quantity of fat stored was equal to this and one gram more. If, on the other hand, the body has lost fat, this loss measures the excess of metabolized fat over that of fat stored from the food, but in neither case do we know the amount of body fat metabolized. What we do learn is the amount of this difference.

The determination of the income and outgo of protein may be illustrated by an actual experiment.¹ The question was this: From a given quantity of the protein of muscular tissue how much will be digested by a healthy man, and will the quantity digested suffice to maintain the supply of protein in his body? In other words, will the man gain or lose protein, or will he simply hold his own on this diet? The subject was a medical student. For protein he ate, in the case here cited, very lean beefsteak. This contained, along with protein, a very small quantity of fat in the form of minute particles which could not be removed with shears and forceps. The diet consisted of the beefsteak cooked with butter, seasoned with pepper, salt, and Worcestershire sauce, and taken with water, beer, and wine. The experiment lasted 3 days. The total quantity of nitrogen of the food was somewhat over 39 grams, of which 38.5 grams were digested, while the rest was excreted in the undigested residue with a small amount of metabolic nitrogen which is not taken into account here. Thirty-seven and two-tenths grams were excreted daily by the kidneys. Assuming that the digested nitrogen of the food represents the income of protein, the gross income of nitrogen, then, is represented by the digested nitrogen of the food, the gross outgo of digested nitrogen by that excreted through the kidneys. Each of these quantities of nitrogen corresponds to a definite quantity of protein which we assume to be equivalent to $6\frac{1}{4}$ times the weight of the nitrogen. It is commonly assumed that for every gram of protein there will be about $4\frac{1}{3}$ grams of muscle, tendon,

¹W. O. Atwater. Ueber die Verdaulichkeit des Fischfleisches. Ztschr. Biol., 1888, p. 16.

etc., in the meat, and that there will be the same ratio between the weight of muscular tissue consumed in the body and the protein, the nitrogen of which is excreted by the kidneys. That is to say, for every gram of digested nitrogen of the income and outgo there will be $6\frac{1}{4}$ grams of protein and $(6\frac{1}{4} \times 4\frac{1}{3})$ about 27 grams of muscle, exclusive of fat.

The gain, then, may be put thus. On a diet of 2 pounds and 10 ounces of lean meat and an ounce of butter per day, was the store of protein in this man's body increased or decreased? In other words, so far as muscular tissue is concerned, did he gain or lose or hold his own? Here are the figures:

Income and outgo of digested nitrogen in experiment with a man on diet of lean meat.

	Grams.
Total nitrogen (per day)	38.5
Nitrogen, kidneys (per day)	37.2
Balance stored in the body (per day)	1.3

That is to say, this young, vigorous man, a student, at his ordinary occupations, studying in his room, listening to lectures at the university, working several hours each day in the laboratory, walking a little for exercise, and living on a diet of protein with a very little fat, gained nitrogen at the rate of 1.3 grams per day. These 1.3 grams of nitrogen represented about 8.2 grams of protein or 35 grams ($1\frac{1}{4}$ ounces) of muscle gained per day during the three days of the experiment. In other words, so far as the lean flesh in his body was concerned he just a little more than held his own.

The difference, that is to say, the gain or loss of fat or of protein, is determined by comparison of income and outgo of material, and thus gives the resultant metabolism of body material. This resultant metabolism of body material expressed in the form of gain or loss of protein or fat must be used in measuring the metabolism of energy. As the factors for this measurement, we may have the total potential energy of the food, the energy of material gained by the body or lost from it, and the energy given off from the body in the form of heat radiated or external mechanical work performed. The income of energy will include the potential energy of the food, and the outgo of energy that of the heat radiated and exterior mechanical work done. If there is a gain by the body in the form of protein or fat; that is to say, if it stores from the food more protein or fat than it consumes of its own substance, the outgo of energy will be diminished by the potential energy of the protein or fat thus stored. If, on the other hand, the body loses protein or fat; that is to say, if it consumes more of its own material than it stores from the food, the potential energy of the material thus lost will go to increase the energy of the outgo. It is clear, therefore, that if we are to study the energy of income and outgo accurately, we must not only determine the energy of the food and that of the heat radiated and exterior

mechanical work done, but also the energy of the body material gained or lost. The amount of material gained or lost is determined by comparison of the income and outgo of nitrogen, carbon, and other elements.

THE RESPIRATION APPARATUS.

The experiment above described sufficed to show the nitrogen and protein balance. It showed that the diet of meat and butter with protein and fat sufficed not only to keep up the store of protein in the body for the three days, but also to slightly increase it; but the experiment does not show whether these nutrients supply the body with heat and muscular energy, or whether some of the fat of the body was consumed to make up for the deficiency in the diet.

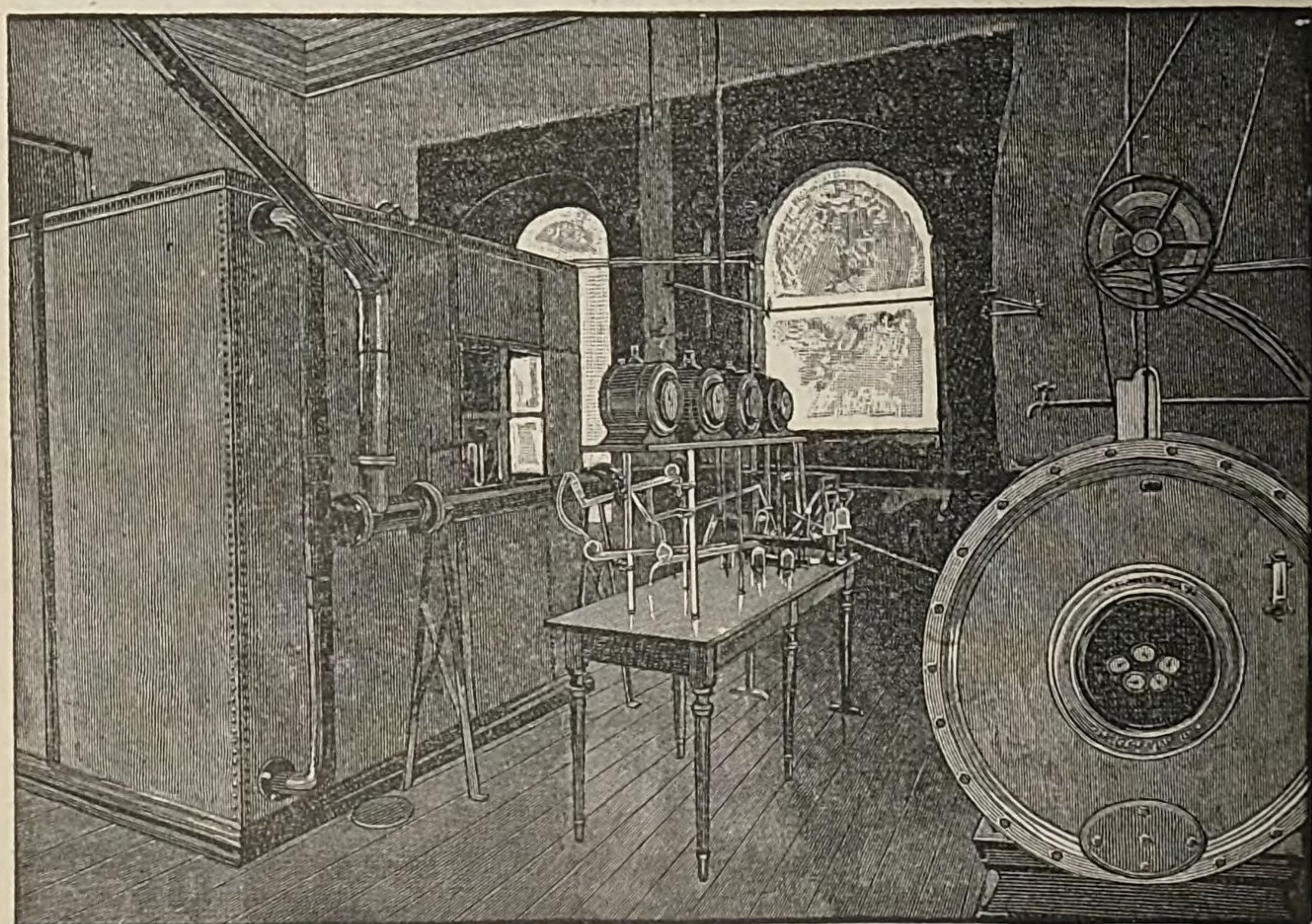


FIG. 5.—Pettenkofer's respiration apparatus.

The only way to answer this question is to measure the income of other elements and especially of carbon. For this purpose the respiration apparatus is used.

To attempt a description of all of the forms of respiration apparatus which have come into use during the past 40 years and the results of the experiments made with them would far exceed the limits of the present article. The most interesting form and the one which has thus far been most useful is that of Pettenkofer. The following description of this apparatus and of some of the experiments performed with it though originally intended for a more popular exposition, will perhaps suffice for the present purpose:¹

¹The description and illustrations are taken from an article by the writer in the *Century Magazine* for June and July, 1887.

The respiration apparatus is a device for measuring the respiratory products. Many forms have been devised, from one in which the products of respiration of a piece of muscle taken from an animal just killed can be measured, the respiratory process being maintained by artificial circulation of blood through the muscle, to one in which an ox may be kept for days or weeks, and the composition of the inhaled and exhaled air likewise determined.

A very interesting form is that used by the French experimenters, Regnault and Reiset a number of years ago. This was a small chamber of glass, inside of which the animal was placed, some rather complicated appliances being used to continually renew the supply of oxygen and remove the carbonic acid and other products of respiration. But from insufficient ventilation and other minor difficulties this form of apparatus has not quite sufficed for satisfactory experiments, especially with the larger animals and with man.

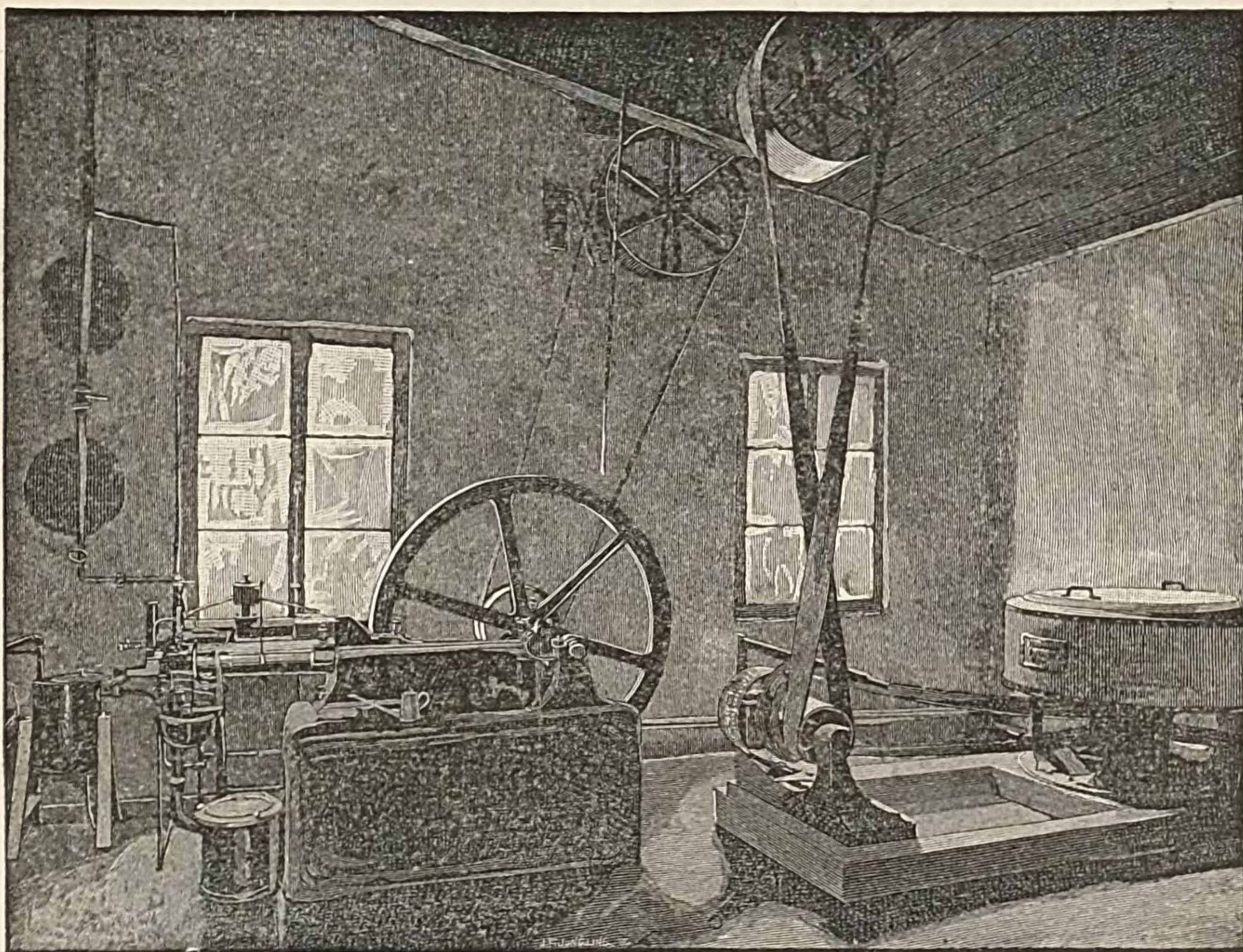


FIG. 6.—Pettenkofer's respiration apparatus. Pumping machinery.

By far the most satisfactory apparatus is that invented by Professor Pettenkofer, of Munich. This is one of the most interesting devices of modern experimental science. The first one was built through the munificence of the King of Bavaria.

The peculiar features of this apparatus are that the subject of experiment, be it a dog, an ox, or a man, is in a comfortable, well ventilated room, and that the air, which passes through it in a continuous current, is measured and is analyzed both before it goes in and after it comes out. We can thus tell just what the animal has added to it—in other words, what material has been given off as gas or vapor from the body. The arrangements do not provide for estimating all the respiratory products with absolute exactness, but they suffice for reasonably accurate results. The form used for experiments with man consists of a chamber—a “salon,” it is called; as a matter of fact it is an iron box—through which a current of air is drawn by a large pump, the latter being worked by an engine.

The salon of the large apparatus at Munich is made of plates of iron, similar to boiler iron, and is in the form of a cube about eight feet each way. It has glass

windows, and a door large enough to admit a man. The large engraving (fig. 5, p. 106) shows the apparatus as it is now arranged. On the left is the chamber in which the man under experiment stays; near are a table holding apparatus for analyzing the air before and after it passes through the chamber, and a large meter for measuring the quantity of air which passes through. In an adjoining room is the machinery by which the current of air is pumped through the apparatus. The smaller sketch

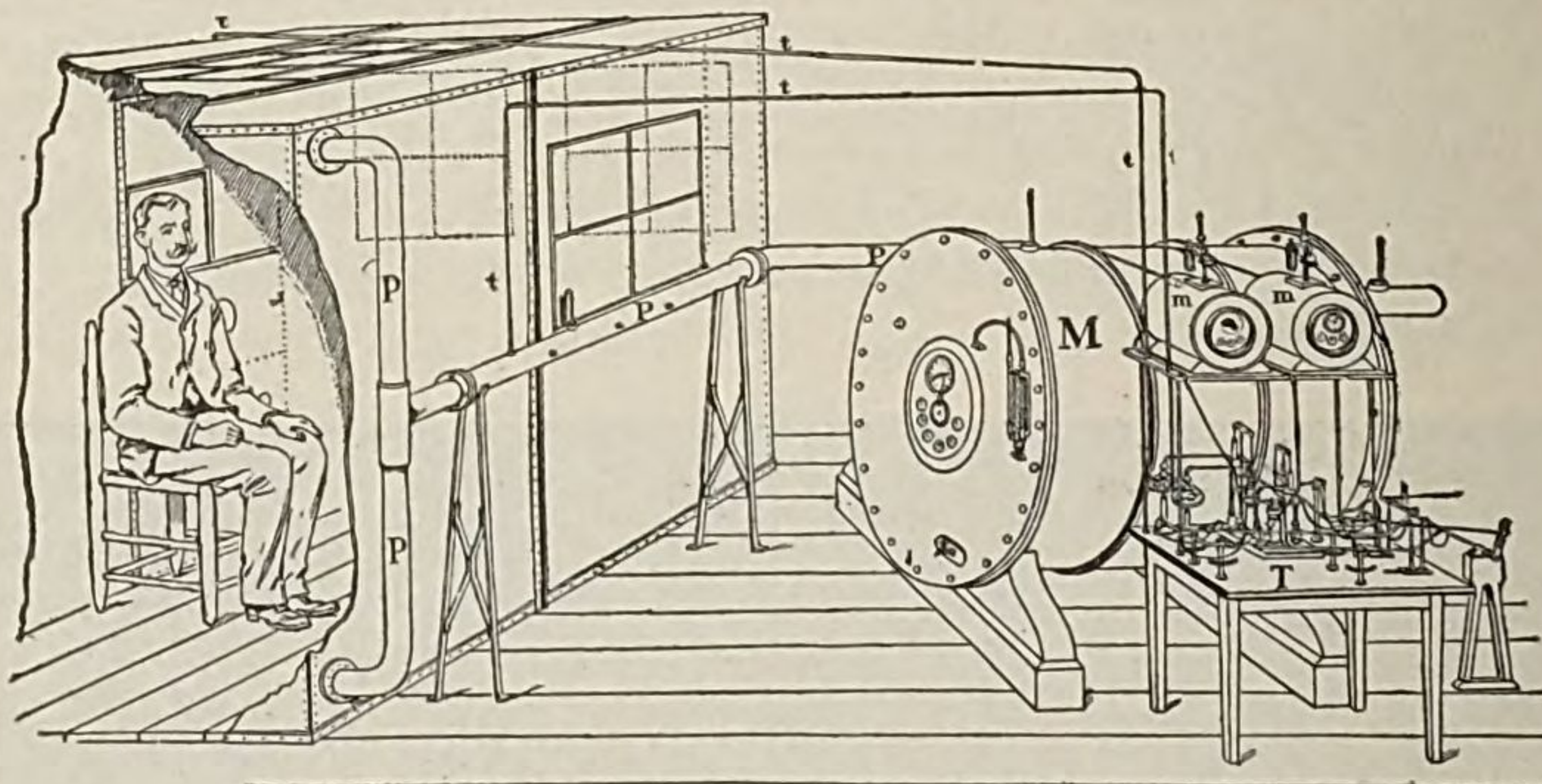


FIG. 7.—Pettenkofer's respiration apparatus. Explanatory sketch.

explains the working in more detail. The air enters the chamber at its left side and passes out on the right through the large pipe P P into the large meter M, in which it is measured. A small tube *t t* takes from the pipe P P a portion of the air, which has been passed through the chamber and contains the products of respiration, into two small meters *m m*, where it is measured, and through the apparatus on the table T, where it is analyzed. A similar small tube *t' t'* brings air for analysis

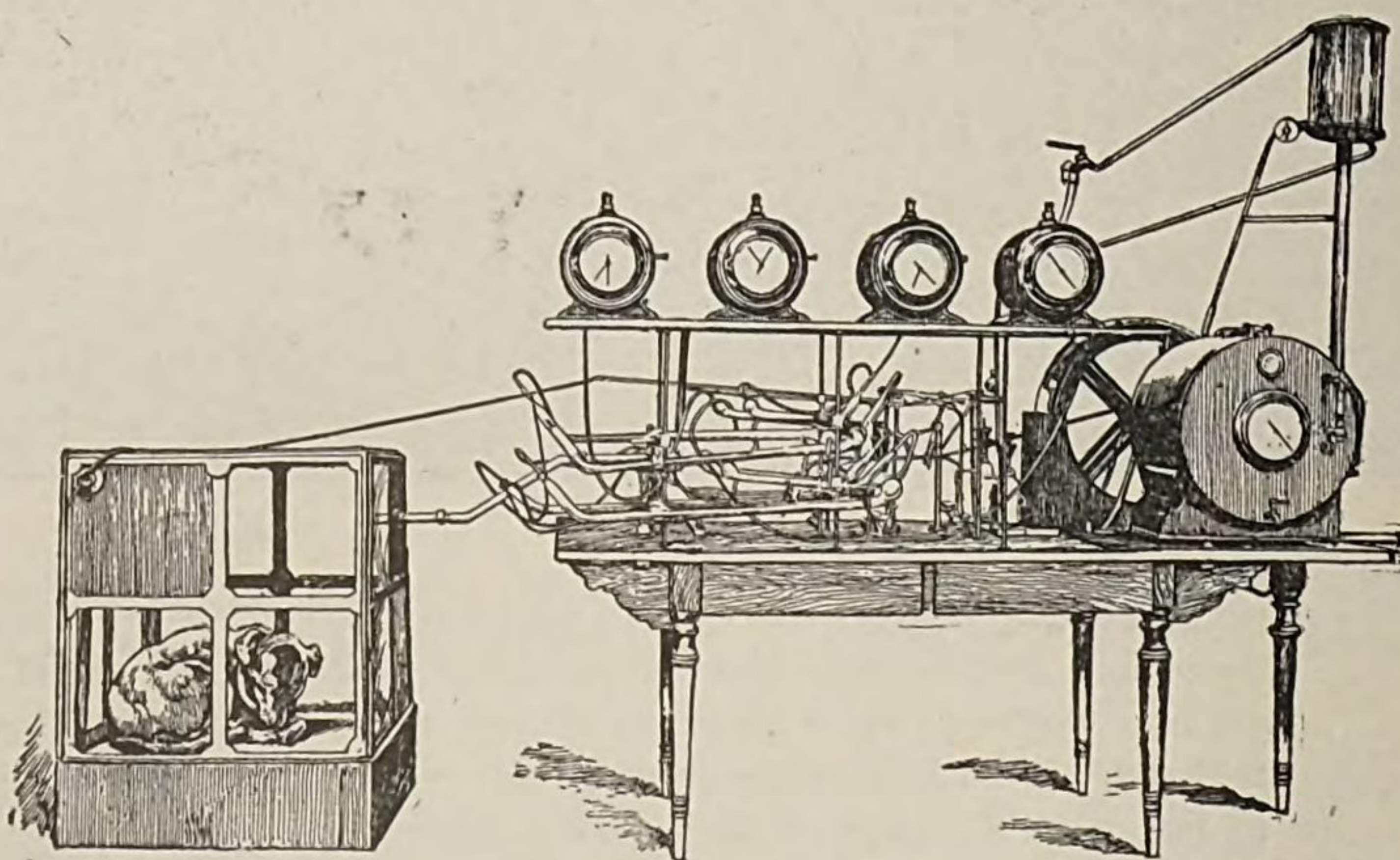


FIG. 8.—Voit's respiration apparatus.

from the outside of the apparatus, taking it from the left of the chamber where it enters the latter and carrying it into two other small meters (not shown in this sketch), where it is measured, and through apparatus, also not shown here, by which it is analyzed. In the engraving (p. 106) the four small meters and apparatus for analyzing the air are shown on the table between the chamber and the large meter. Comparisons of the quantity and composition of the air which has passed through

the chamber with the outside air show what the man has imparted to the air in breathing, and thus tell the amounts of the products of respiration. The food and drink and the solid and liquid products of its consumption in the body are at the same time measured, weighed, and analyzed, and thus all of the items of income and outgo of the body are determined.

Figure 9¹ represents a smaller form of respiration apparatus devised by Voit. It is identical in principle with the larger apparatus. It is intended for experiments with dogs, geese, and other small animals. Its object is to provide for analysis of the air before and after it has been breathed by the animal, and thus show what products of respiration the animal has imparted to it. The box in which the animal is kept is made of glass. Through this box a constant current of air is drawn and measured by the large meter on the table. A small portion of this, however, is drawn through two of the small meters by which it is measured, and through apparatus on the table by which it is analyzed. Air taken from outside the box is at the same time drawn through the other two small meters and apparatus on the table, and thus measured and analyzed in like manner.

The first man to enter the respiration apparatus for experiments upon himself, I believe, was Professor Ranke, of Munich, who has described his experiences in his book on *The Nutrition of Man* (*Die Ernährung des Menschen*), as well as in special memoirs. He tells us that in trials in which he took no food the fasting was somewhat disagreeable, but far less painful than many would think. "I found myself at the end of the first 24 hours entirely well; at the end of the second 24 hours without food or drink, during which sleep had been disturbed, the head was somewhat heavy and there was an oppressiveness in the stomach and considerable weakness; but the sensation of hunger, * * * which was strongest about 30 hours after the last food was taken, * * * did not appear any more."

In the greater number of Professor Ranke's experiments he took a reasonable amount of food. The diet was simple, and consisted of such materials as lean meat, bread, white of egg, starch, sugar, butter, etc., and was found to serve the purpose very well. After some experience a ration was arranged which corresponded very well in composition with that used by ordinary working people, and was at the same time not at all unacceptable. When a number of experiments with Professor Ranke had been completed, several series were made with other persons. One of these latter series I will briefly describe.

The subject was a strong, healthy mechanic, a watchmaker, 28 years old, and weighing about 156 pounds. Three experiments were made, each occupying 24 hours. In the first, the man took nothing but a little meat extract, salt, and water, and did no work. In the second, he had a liberal allowance of palatable food, but still remained at rest. In the third, he had the same diet as in the second, but worked hard at turning a lathe for 9 hours, so that he was thoroughly tired at night. During the daytime of the first two experiments, I should say, he read, cleaned a watch, and otherwise occupied himself to while away the time, making, however, very little muscular effort.

The three experiments, then, show the effects of fasting and rest, food and rest, and food and muscular exercise upon the income and outgo of this man's body. We will note only very briefly some of the details of the experiments, the full accounts of which fill many pages.

The diet of the first experiment consisted of: Meat extract, 12.5 grams (a little less than one-half ounce); salt, 15.1 grams (a little over one-half ounce); water, 1027.2 grams (about a quart).

The day's ration of the second trial included a third of a pound of lean meat, a pound of bread, a little over a pint of milk, and about a quart of beer, and other materials as follows:

¹Century Magazine, XXIV, 1887, p. 402.

Day's food in second experiment.

	Grams.
Meat, lean beef	140
Egg albumen (white of egg)	42
Bread	450
Milk	500
Beer	1,025
Lard	70
Butter	30
Starch	70
Sugar	17
Salt	4
Water	286

The diet of the third experiment was essentially the same as that of the second, except that the man drank a little more water.

The income included, besides the food and drink, the oxygen consumed from the inhaled air. The estimated quantities were:

Oxygen used in 24 hours.

	Grams.
First experiment, fasting and at rest	779
Second experiment, liberal ration and at rest	709
Third experiment, liberal ration and at work	1,006

The final balance sheets of the experiments, which show the details of income and outgo in terms of the chemical elements, carbon, nitrogen, etc., are too extensive to be reported here. That for each experiment would nearly fill one of these pages, but as some readers may be curious to see what they are, I give the principal data in abbreviated form:

Daily income and expenditure of chemical elements.

	Carbon.	Hydrogen.	Nitrogen.	Oxygen.
Experiment with no food (except meat extract) and no work:	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Income	2.4	115.1	1.2	1698.4
Outgo	209.5	221.6	12.5	2301.4
Loss	207.1	106.5	11.3	603
Experiment with liberal ration of meat, milk, bread, etc., and no work:				
Income	515.5	270.9	19.5	2712.9
Outgo	275.7	248.2	19.5	2630.2
Gain	39.8	22.7	0.0	82.7
Experiment with liberal ration, as in preceding experiment, and hard work:				
Income	309.2	297.7	19.5	3232.5
Outgo	336.3	304.9	19.5	3246.5
Loss	27.1	7.2	0.0	14

But we wish to know what quantities of flesh and fat the man gained or lost under these different conditions of food and fasting, labor and rest. The figures just cited are for the chemical elements of which the protein and fats are composed. Knowing the proportions of the elements in each compound, it is easy, from the figures for the elements, to estimate the quantities of the compounds. Omitting details of the calculations the results are given in the balance sheet of compounds herewith. Regarding the carbohydrates, however, I should explain that since the body has extremely little of its own, and those of the food are consumed, they are left out of account in the experiment without food, and the amounts received and consumed in the experiments with food are taken as balancing one another.

Income and expenditure of chemical compounds by body of man.

	Fasting (no work).			Liberal ration (no work).			Liberal ration (hard work).		
	Pro- tein.	Fats.	Carbo- hy- drates.	Pro- tein.	Fats.	Carbo- hy- drates.	Pro- tein.	Fats.	Carbo- hy- drates.
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Income.....	7	0	None.	122	117	332	122	117	352
Outgo.....	78	216	None.	122	52	332	122	173	352
Gain +, or loss —	—71	—216	None.	0	+65	0	0	—56	0

The protein gained or lost was mainly from the muscles and similar tissues, or what we may call flesh as distinguished from fat. Taking the figures for protein and fats gained and lost as shown in the last line of the balance sheet of income and expenditure of compounds, changing grams to ounces, and assuming that with each ounce of protein would be water, etc., enough to make the equivalent of $4\frac{1}{2}$ ounces of lean flesh, i. e., muscle, tendon, etc., we have this final result of the trials; the quantities, as before, are those gained or lost in one day:

Outcome of the experiments as regards increase or decrease of lean flesh and fat within the body.

	Lean flesh (muscle, etc.).	Fats.
	<i>Ounces.</i>	<i>Ounces.</i>
No food, no work, loss.....	11	$7\frac{3}{4}$
Liberal diet, no work, gain.....	None.	$2\frac{3}{4}$
Liberal diet, hard work, loss.....	None.	2

That is to say, fasting, and without muscular labor, the man lived upon the tissues of his body, and consumed daily a trifle less than three-quarters of a pound of muscle, and with this nearly half a pound of the fat previously stored in his body. With plenty of food, and still resting, he neither gained nor lost lean flesh, but gained $2\frac{1}{8}$ ounces of fat in a day. And when he set himself to hard muscular work, with the same amount of food, he likewise held his own so far as lean flesh was concerned, but lost 2 ounces of fat. The body used for its support protein and fats, in each case, and carbohydrates when it had them. When the nutrients were not supplied in food, it consumed a little protein and a good deal more fat from its own store. With a ration which sufficed to exactly maintain its protein without gain or loss, the body gained fat when it had only a little more than its own muscular work to perform (that included in breathing, keeping the blood in circulation, etc.), and lost fat again when this work was increased by manual labor.

If we had only these experiments to judge from, we might infer that muscular energy comes from consumption of fat, and that the special work of the protein of the food is to repair the wastes and make up for the wear and tear of the protein of the body; and this would be true as far as it goes. But, of course, many other experiments and of many different kinds are needed to settle these questions. The majority of the most useful ones, thus far, have been made with other animals than man.

In studying the laws of animal nutrition the most convenient organism, for many purposes, is that of the dog. The dog thrives upon both animal and vegetable foods, utilizes large quantities of food to advantage or endures long fasting with patience, and makes ready responses by changes of bodily condition to changes in the food. In reading the accounts of the famous feeding trials conducted by Bischoff and Voit, one is surprised to see what control they obtained of the organisms of the dogs experimented with. By altering the kinds and quantities of food constituents, Voit was able either to reduce both the flesh (protein) and the fat of the

animal's body or to increase both flesh and fat, or to reduce the one or to increase the other. Indeed, the manipulations effected in this way seemed almost equivalent to getting into the tissues and directly removing or adding flesh or fat at will. The principles thus learned from experiments with the dog and other animals apply in the main, though not in all the details, to the nutrition of man.

The effect of one-sided diet is very well illustrated in some experiments by Professor Ranke. They were made in the respiration apparatus at Munich, and belonged to the series of which I have already spoken. After he had studied the changes that went on in his body when fasting, he proposed to himself these questions:

What will be the effect of a diet of protein with very little fat and no carbohydrates on the one hand, and of a diet of fats and carbohydrates without protein on the other? In other words, how will the composition of the body be affected by food rich in protein and containing little else, and how will the store of fat and protein be altered by leaving the protein out of the food and living on the other nutrients?

For the diet of protein, he took lean meat, with butter and a little salt, essentially the same diet as was used by the student in the experiment described above. He had found himself able to eat 2,000 grams of the lean meat in the course of the day, but in this experiment, which lasted 24 hours, he ate only 1,833 grams (about 4 pounds) of meat and with it 70 grams of fat, 30 grams of salt, and 3,371 grams (nearly 3 quarts) of water. Without going into the details, suffice it to say, that, according to Professor Ranke's calculations, his body lost 15.1 grams of fat and at the same time gained 113 grams of protein during the day of the experiment. In the other experiment, which likewise continued for 24 hours, the food consisted of 150 grams of fat, 300 grams of starch, and 100 grams of sugar, an even less appetizing mixture perhaps than the lean meat and butter for an exclusive diet, but yet one which, if put together with proper culinary skill, makes a cake that can be swallowed. This time he lost 51 grams of protein and gained 91.5 grams of fat.

The results of these two experiments may be recapitulated thus: On the diet consisting chiefly of protein (lean meat, etc.) the body gained protein (muscle, etc.) and lost fat. On the diet consisting chiefly of fats and carbohydrates (starch and sugar) the body lost protein and gained fat. This is just what we might expect. But it is interesting to have the facts and figures to show exactly what did take place, and other experiments make it safe to say that if either the quantities of food or the condition of Professor Ranke's body had been different, the results would have been different also. Thus in the first experiment if he had eaten less meat he would have stored less protein; indeed, with a small enough ration he would have lost both protein and fat, and it seems probable that if he had not been a rather fat person he would not have lost fat so readily on the protein diet.

Experiments confirm and to some extent explain the fact so well attested by general experience, that a mixed diet is best for ordinary people in health. Professor Ranke found that when he did no muscular labor, his body neither gained nor lost; that, in other words, he just about "held his own" with food, containing per day: Protein, 100 grams (3.5 ounces); fats, 100 grams; carbohydrates, 240 grams (8.5 ounces).

CHAPTER VII.

METABOLISM OF ENERGY—INCOME AND OUTGO OF BODY.

In considering the metabolism of energy we have to deal with the principles of thermo-chemistry as applied to animal and vegetable organisms. For the present purpose we may confine our attention to the changes which go on in the animal body. The principles to be applied may be expressed in various ways. They are enunciated by Berthelot in the following terms:¹

I. *Principle of molecular [atomic] work.*—"The quantity of heat evolved is the measure of the sum of the chemical and physical work accomplished in any reaction."

II. *Principle of conservation of energy.*—"When a system of bodies—simple or compound—starting from a given condition undergoes either physical or chemical changes, which bring it into a new condition without producing any mechanical effect on external bodies, the amount of heat evolved or absorbed, as the total result of these changes, depends solely on the initial and final states of the system, and is the same, whatever may be the nature or order of the intermediate states."

III. *Principle of maximum work.*—"In any chemical reaction between a system of bodies not acted on by external forces the tendency is toward that condition and those products which will result in the greatest evolution of heat."

It is with the second and third of these principles, and especially the second, that we have to do. In discussing this subject Professor Cooke says:

We readily accept Berthelot's second fundamental principle of thermo-chemistry when enunciated as above, because it so obviously falls under the general law of conservation of energy; but it is obvious that this principle could not have been assumed prior to its experimental verification any more than could the principle of the conservation of mass prior to the experiments of Lavoisier, and as Lavoisier worked out this last great principle with the balance, so Berthelot and Thompson have demonstrated with the calorimeter the corresponding fundamental principle of thermo-chemistry, which must be regarded as a generalization from the results of their work. Moreover, although in cases of simple direct combination the principle under discussion is almost self-evident and has been long admitted, yet before the investigations of Berthelot and Thompson no chemist conceived of its application in the very complex and indirect reactions by which the greater part of the thermo-chemical data have been obtained.

In like manner it may be said that the application of the second and third of these principles, and especially the second, in the living organism has long been believed, but has lacked the absolute demonstration. During the past ten years, however, an approach to such demon-

¹Essai de mécanique chimique, Tome I, Introduction, pp. xxviii, xxix. See also J. P. Cooke in Amer. Jour. of Sci., bd. ser., XIX, pp. 261-267; and Pattison-Muir, Thermal Chemistry, pp. 297 and 245, note.

stration has been made by several experimenters, notably by Rubner in experiments with dogs, and although these have not the completeness necessary to place the principle beyond all peradventure, and especially to show the details of its application, they suffice to confirm the belief in the general application of the principle.

The experimental study of this question is carried on in two lines.

Potential energy—Heats of combustion determined by the bomb calorimeter.—The first of these kinds of inquiry has to do with the determining of the potential energy of the materials concerned in the metabolic processes. These materials are (1) the nutrients, i. e., protein, fats, carbohydrates, etc., of the food; (2) the substances, mainly protein and fats, which are either stored in the body or taken from the store contained in the body and consumed; and (3) the excreted compounds which are not completely oxidized and which in consequence still contain potential energy; these are chiefly the urea and other organic compounds excreted by the kidneys and the undigested residue of the food. The heats of combustions of the compounds, as determined by oxidation in the bomb calorimeter, are taken as the measure of their fuel value.

Income and outgo of energy in the body—Respiration calorimeter.—The second branch of the inquiry concerns itself with the balance of energy in the body. It involves the determination of the total income and outgo expressed in terms of both matter and energy. The income and outgo of matter are determined by the aid of a respiration apparatus, which shows the quantities of chemical elements and compounds taken in and given off by the body, and inferentially the quantities of material which are either stored in the body during the experiment or consumed from its previous store. The income of energy is represented by the potential energy of the materials which constitute the income of matter. Their potential energy is learned from the heats of combustion developed when they are burned with oxygen in the calorimeter. The outgo of energy is made up essentially of three factors. One is the potential energy of the excreta, which is determined by burning with oxygen in the calorimeter; another and the principal one is the heat radiated from the body. To measure this, different appliances have been used. The most successful results thus far published have been obtained by Rubner with a respiration apparatus which has special arrangements for determining the quantity of heat radiated from the body. Perhaps the most convenient designation for such forms of apparatus is that here used—respiration calorimeter. The third factor is the mechanical work done by the body, i. e., that which manifests itself as external work, and not including the internal work such as is involved in respiration and the circulation of the blood. The heat equivalent of this external mechanical work, added to the heat radiated from the body and the heat of combustion of the excreta, would make up the total outgo of energy. No successful attempt to measure all these factors in the same experiment has yet been published.

In the study of the nutrition of man in relation to his health and

useful work the sources, nature, and economy of intellectual energy constitute a most important factor, but one upon which chemical physiology has as yet thrown very little light.

POTENTIAL ENERGY OF FOOD—HEATS OF COMBUSTION—FUEL VALUES.

The food performs essentially two functions in the body—the building and repair of tissue and the yielding of energy. In being consumed the nutrients yield energy in the form of either heat or muscular power. Part of this potential energy becomes kinetic in the cleavage of complex compounds to simpler ones; part is liberated in the processes of oxidation. Neither the chemical nor the physical changes which take place are now fully understood. Of this much, however, we are certain: The processes are complex, and although the ultimate chemical products may be the same as those of direct oxidation, the processes by which they are formed in the body are much more complex than those which take place when they are burned either in the furnace or the calorimeter. But it is believed that, in accordance with the principle of the conservation of energy, the quantity of potential energy which is transformed into kinetic energy will be the same in the one case as in the other, provided the final products are the same. Furthermore, in accordance with the principle of maximum work the tendency is toward those changes which result in the greatest evolution of heat or other form of kinetic energy. We may therefore take the heats of combustion of the nutrients of the food as equivalent to their potential energy; we may also take this potential energy as the measure of their fuel values, i.e., their value for the production of heat and muscular work when they are consumed in the body. The same principle applies to the materials, mainly protein and fats, which the body takes from the food and makes a part of its tissue before they are consumed. It applies also to the incompletely oxidized excretory products like urea and to the undigested residue of the food which is excreted by the intestine, in so far as their potential energy is concerned. That is to say, if we subtract the potential energy of these products from that of the total material from which they are formed the difference will be the amount of energy which has been liberated in their consumption in the body. If, however, a portion of the food has been stored as part of the tissue of the body, the potential energy of the compounds thus stored must also be subtracted from that of the total food in order to learn the quantity of energy actually liberated. Speaking in general terms, then, the quantity of heat which is set free when a given food material is burned with oxygen in the calorimeter may be taken as the measure of the fuel value of that food material.

Such is the theory. It needs further experiment for complete demonstration, but the balance of probability is now very strongly in its favor, and growing more and more so as accurate research accumulates. It becomes very important, therefore, to determine accurately the heats of combustion of the ingredients of food and their metabolic products,

CALORIMETERS AND CALORIMETRY—HISTORICAL DEVELOPMENT.

The history of calorimetry as applied to determining the heats of combustion of organic substances is too comprehensive a subject for treatment here, but a brief review of the part of it which bears most directly upon the fuel values of the compounds concerned in metabolism will not be out of place.

THOMPSON'S CALORIMETER—INVESTIGATIONS OF FRANKLAND.

In determining the heats of combustion of such compounds two distinct forms of apparatus have been employed. In both the substance is burned with oxygen and the heat is measured by the rise of temperature of a certain weight of water to which the heat is communicated. The older one is that of Lewis Thompson.¹ This was used for determining the heats of combustion of organic compounds as early as 1866.² The apparatus consisted eventually of a stout copper cylinder closed at the bottom and standing upright inside a so-called "diving bell," also of copper. The cylinder and diving bell were immersed in a suitable vessel containing 2 liters of water. In performing the experiment a given weight, about 2 grams, of the substance, whose thermal value was to be determined, was intimately mixed with 19.5 grams of potassium chlorate, to which about 2.5 grams of manganese dioxid had been added. This mixture was placed in the cylinder; a small piece of cotton, previously steeped in a solution of potassium chlorate and dried, was inserted as a fuse. The temperature of the water was then carefully ascer-

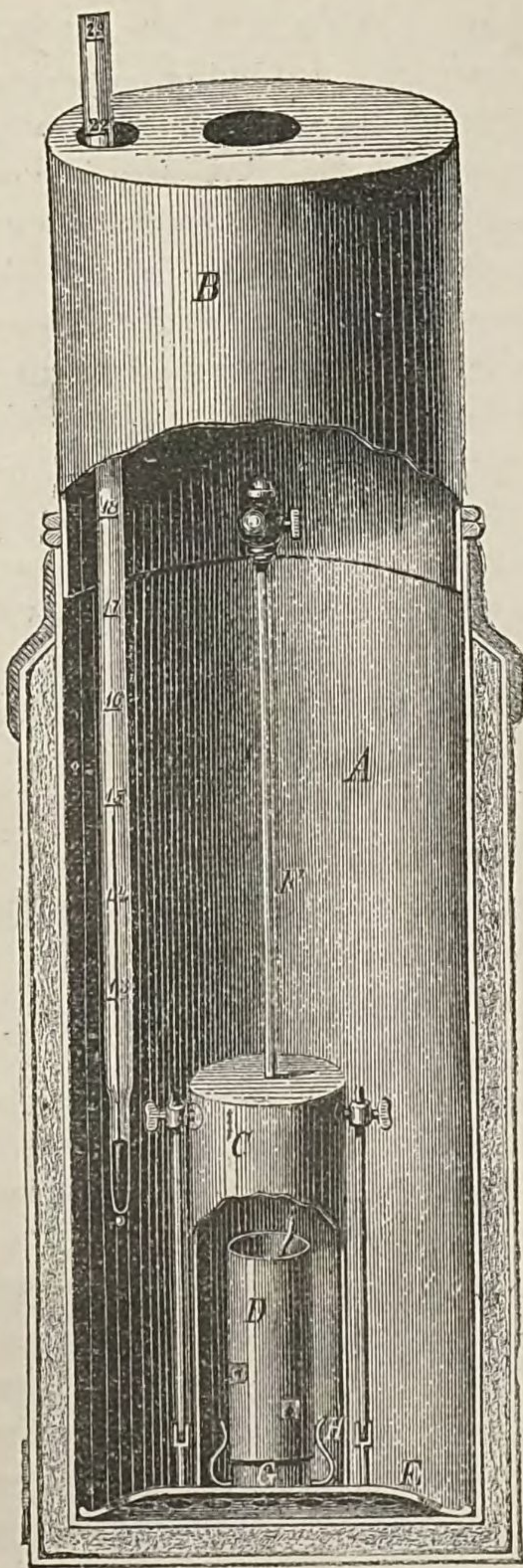


FIG. 9.—Thompson's calorimeter.

tained by a delicate thermometer, and, after the end of the cotton thread had been ignited, the tube, with its contents, was placed in the

¹Described briefly by Frankland, Proc. Roy. Inst. of Great Britain, June 8, 1866, and Phil. Mag. [4], 32, 182.

²Loc. cit. See also résumé of subject by Stohmann, Jour. prak. Chem. (N. F., 19), 1879, 115.

bottom of the copper diving bell and lowered to the bottom of the water. When the mixture burned the gaseous products of combustion issued from numerous small openings at the bottom of the bell and rose to the surface of the water—a height of about 10 inches. At the end of the deflagration the water was admitted to the diving bell and replaced the remainder of the gaseous products, which were allowed to escape through a small tube. The water was well mixed by moving the bell up and down repeatedly, and its temperature was again carefully observed. The rise in temperature of the water, compared with its specific heat, gave the quantity of heat liberated in the combustion. Corrections were applied for (1) the heat absorbed by the apparatus, and (2) the heat evolved by the decomposition of the chlorate of potassium, the former being added to and the latter subtracted from the heat given off in the combustion, as measured by the rise in the temperature of the water. Both corrections were determined experimentally once for all, and the values thus obtained were applied in each determination of the heats of combustion of the substance studied. A series of determinations were made by Frankland, who states the results as follows. The heat units are small calories:

Actual energy developed by 1 gram of each substance when burnt in oxygen.

[Heat units.]

Name of substance (dried at 100° C.).	Experiment.				
	First.	Second.	Third.	Fourth.	Mean.
Beef muscle purified by repeated washing with ether	5,174	5,062	5,195	5,088	5,103
Purified albumin	5,009	4,987	.....	.....	4,998
Beef fat	9,069	.....	.....	.....	9,069
Hippuric acid	5,330	5,437	.....	.....	5,383
Uric acid	2,645	2,585	.....	.....	2,615
Urea	2,121	2,302	2,207	2,197	2,206

The special purpose of these investigations was to get information regarding the quantity of energy which could be developed in the body from the consumption of protein. With reference to this question, Frankland makes the following statements and calculations:

It is evident that the above determination of the actual energy developed by the combustion of muscle in oxygen represents more than the amount of actual energy produced by its oxidation within the body, because when muscle burns in oxygen its carbon is converted into carbonic anhydrid, and its hydrogen into water, the nitrogen being to a great extent evolved in the elementary state; whereas when muscle is most completely consumed in the body the products are carbonic anhydrid, water, and urea; the whole of the nitrogen passes out of the body as urea, a substance which still retains a considerable amount of potential energy. Dry muscle and pure albumin yield, under these circumstances, almost exactly one-third of their weight of urea; and this fact, together with the above determination of the actual energy developed in the combustion of urea, enables us to deduce with certainty the amount of actual energy developed by muscle and albumin, respectively, when consumed in the human body. It is as follows:

Actual energy developed by 1 gram of each substance when consumed in the body.

Name of substances (dried at 100° C.).	Heat units (mean).
Beef muscle purified by ether.....	4,368
Purified albumin.....	4,263

Arguing that the source of animal heat and of muscular power is to be found in the transformation of the potential energy of the food into kinetic energy, and that "from this point of view it is interesting to examine the various articles of food in common use, as to their capabilities for the production of muscular power," Professor Frankland "made careful estimates of the calorific value of different materials used as food with the same apparatus and in the same manner as described above." The results are summarized in the following table:

Results of experiments with food dried at 100° C.

[Heat units.]

Name of food.	Experiment.		
	First.	Second.	Third.
Cheshire cheese.....	6,080	6,149	.....
Potatoes.....	3,752	.....	.....
Apples.....	3,776	3,562	.....
Mackerel.....	5,994	6,134	.....
Oatmeal (not dried).....	4,143	4,018	3,857
Lean beef.....	5,271	5,260	5,410
White of egg.....	4,823	4,940	4,927
Carrots.....	3,776	3,759	.....
Pea meal (not dried).....	3,866	4,006	.....
Flour (not dried).....	3,941	3,931	.....
Arrowroot (not dried).....	3,923	3,902	.....
Butter.....	7,237	7,291	.....
Ham, boiled and lean.....	4,188	4,498	.....
Lean veal.....	4,459	4,595	4,488
Hard-boiled egg.....	6,455	6,187	.....
Yolk of egg.....	6,460	.....	.....
Isinglass.....	4,520	4,520	.....
Cabbage.....	3,809	3,744	.....
Whiting.....	4,520	4,520	.....
Ground rice (not dried).....	3,802	3,824	.....
Cod-liver oil.....	9,134	9,080	.....
Cocoa nibs (not dried).....	6,809	6,937	.....
Residue of milk.....	5,066	5,120	.....
Bread crumb.....	3,984	3,984	.....
Bread crust (not dried).....	4,459	.....	.....
Lump sugar (not dried).....	3,403	3,294	.....
Commercial grape sugar (not dried).....	3,277	3,277	.....
Residue from bottled ale.....	3,776	3,744	.....
Residue from bottled stout.....	6,348	6,455	.....

From the data thus obtained Frankland estimates the quantities of energy actually developed by these materials when oxidized in the body, making allowance for the nitrogenous material which is not completely oxidized. He adds that "it must be borne in mind that it is only on condition of the food being digested and passed into the blood that the results given in these tables are realized, and that the force values experimentally obtained for the different values in these tables, must, therefore, be understood as the maxima assignable to the substances to which they belong." The tables in which the compilations are given are somewhat detailed and need not be repeated here.

STOHMANN'S CALORIMETER AND INVESTIGATIONS.

After the publication of Frankland's investigations in 1866, no further investigations of importance in this direction were announced or undertaken until 1877, when Stohmann began work in Leipsic. His results were first published in 1879. His method was the same in principle as that followed by Frankland. Stohmann, however, gave much attention to the sources of error, and devised a form of calorimeter with which the attempt was made to avoid them.

The figures of Frankland above cited show wide discrepancies in the duplicate determinations of the heats of combustion of the same material. Stohmann's first effort was to trace these discrepancies to their source. The principal causes of error were found in the oxidation of the copper of which the cylinder was made and the irregularity of a secondary thermal process incident to the combustion, namely, the solution of the potassium chlorid formed by the decomposition of the chlorate. The former error was obviated by substituting platinum for copper in the combustion cylinder and the latter was controlled by the direct determination of the potassium chlorid in solution at the end of the combustion. Stohmann used at first an apparatus which was obtained in London and was essentially the same as that of Thompson which Frankland had employed. He soon modified it, however, by making the combustion cylinder of platinum instead of copper, as just stated, and by substituting a vessel of brass in the place of one of glass for holding the water.¹

In the elaboration of the method and finding the sources of error and means of avoiding them, Stohmann, with his two assistants, Dr. Spindler and Dr. von Rechenberg, made "at least a thousand combustions." In the apparatus thus described a layer of nonconducting material (wool) was put around the outside of the brass cylinder which contained the water; no other means was used to prevent the radiation

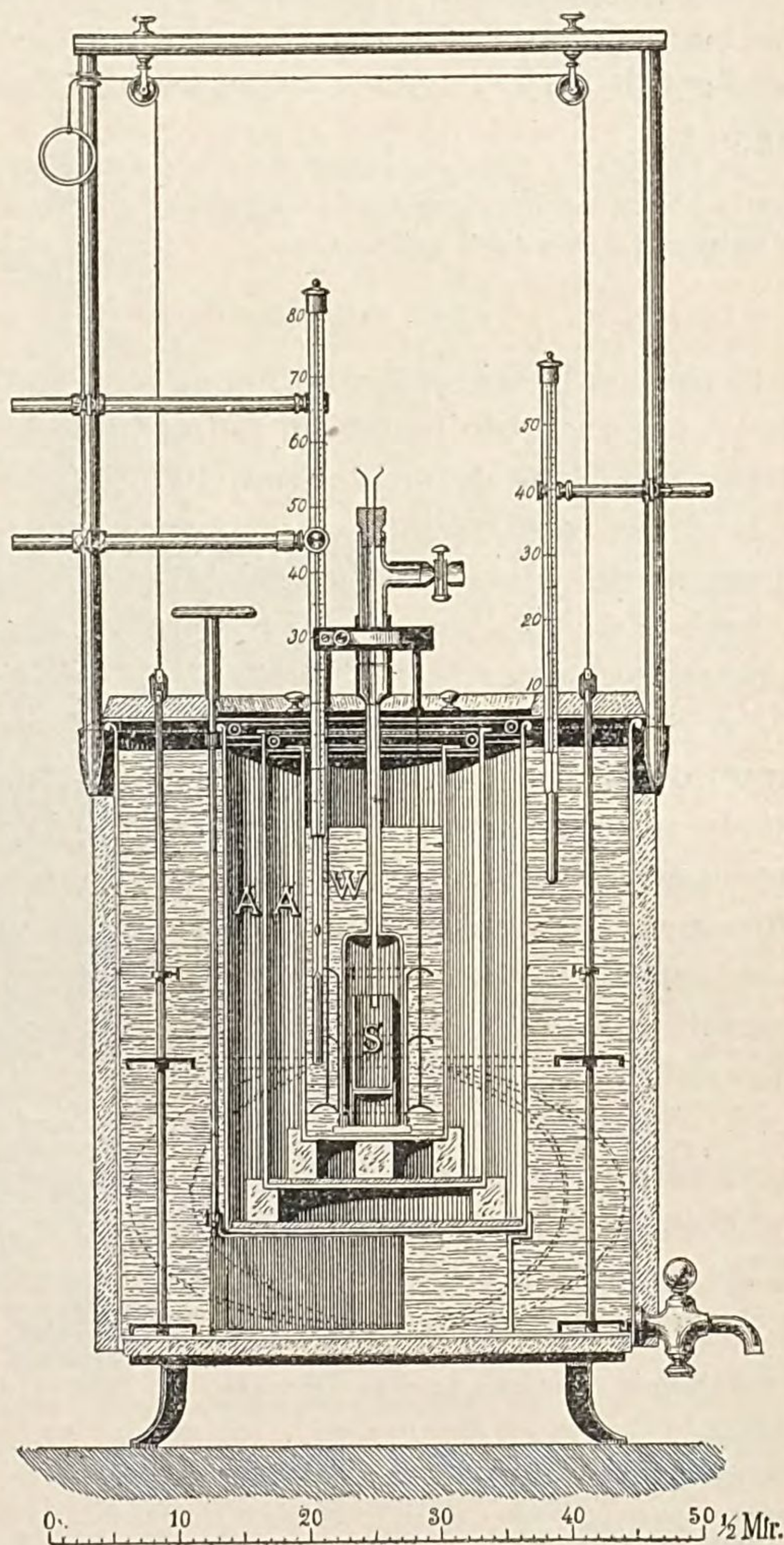


FIG. 10.—Stohmann's calorimeter.

¹ A description of this apparatus with diagram is given by Stohmann in *Jour. prak. Chem.*, 127 (N. F. 19), 1879, p. 115.

of heat from the water in the cylinder outward, or the passage of heat from without into the water. Later, Stohmann provided a series of three concentric copper cylinders. The space in the interior of the inner cylinder which was not occupied by the apparatus was filled with air; the space between this cylinder and the second was also filled with air; that between the second and the outer one was filled with water. The outer cylinder was wrapped in felt. There were thus 2 layers of air, 1 of water, and 1 of felt between the calorimetric apparatus proper and the external air. Mechanical devices were provided for stirring water in the calorimeter so as to secure uniform distribution through it of the heat from the combustion. The temperature of the water was measured by a thermometer with divisions such as to permit reading to one-thousandth of a degree with the aid of a magnifying glass.¹

The apparatus thus perfected was used for ten years or more by Stohmann and his pupils, Von Rechenberg and Danilewski in Leipsic, by Rubner in Munich, and by Gibson in the writer's laboratory.

THE BOMB CALORIMETER OF BERTHELOT.

In the combustions by the Thompson-Stohmann method just described the oxygen is obtained from potassium chlorate. Considerable time is required for the determination, but the chief difficulty with this method is that the combustion is not always complete. Berthelot has devised an apparatus and, with the assistance of Vieille and others, has developed a method for the use of oxygen under high pressure. The apparatus consists essentially of a steel bomb lined with platinum, within which the substance is burned. The bomb is immersed in water contained in a metal cylinder; this calorimeter cylinder is placed with its contents inside of concentric cylinders containing air and water. The heat developed is measured by the rise in temperature of the water, due allowance being made for the heat absorbed by the metal of the apparatus and for that introduced in igniting the substance by an electric current and developed by the oxidation of an iron wire through which the current is passed, and in the formation of a small amount of nitric acid. The reactions are simple, the oxidation of the compounds in completing the determination requires a comparatively short time, and the results are very satisfactory. The only drawback is the great cost of the apparatus which is due to the large amount of platinum employed in its construction.²

The bomb calorimeter was first used by Berthelot in measuring the heats of combustion of gases by detonation. The gas to be burned was mixed with the exact amount of oxygen required, or a slight excess at ordinary atmospheric pressure within

¹See description by Stohmann with diagram; *Landw. Jahrb.*, 13, 1884, 513. It is also pictured in the *Century Magazine*, July, 1887.

²For descriptions see Berthelot. *Ann. Chim. et Phys.* (5), 23, 160; Berthelot and Vieille, *Ibid.* (6), 6, 546; Berthelot, *Traité pratique de calorimétrie chimique*, Paris, 1893, p. 128, and, for an especially clear account of the apparatus and method, Stohmann, *Jour. prak. Chem.*, 147 (N. F. 39), 1889, 503. An engraving of the bomb with a brief description may be found in *Ztschr. analyt. Chem.*, 1893, 77. The apparatus employed by Stohmann was obtained from Golaz in Paris, who made it in accordance with Berthelot's directions. It cost, with accessories, including compression pump, etc., not far from \$1,200.

the bomb and ignited by the passage of an electric spark. Gases were easily burned in this way, but the combustion of solids was impracticable. Attempts were made to remedy the difficulty with solids by intimately mixing them with potassium chlorate and good results were obtained as in the Thompson-Stohmann method. Berthelot and Vieille¹ found later,² however, that when oxygen was introduced under a pressure of from 7 to 25 atmospheres, the combustion was complete with all organic substances even when no potassium chlorate was added.

The bomb originally employed by Berthelot was in the shape of a cylinder, with hemispherical ends and divided in two parts, one of which screwed into the other. It was made of steel with the interior lined with gold by electroplating.

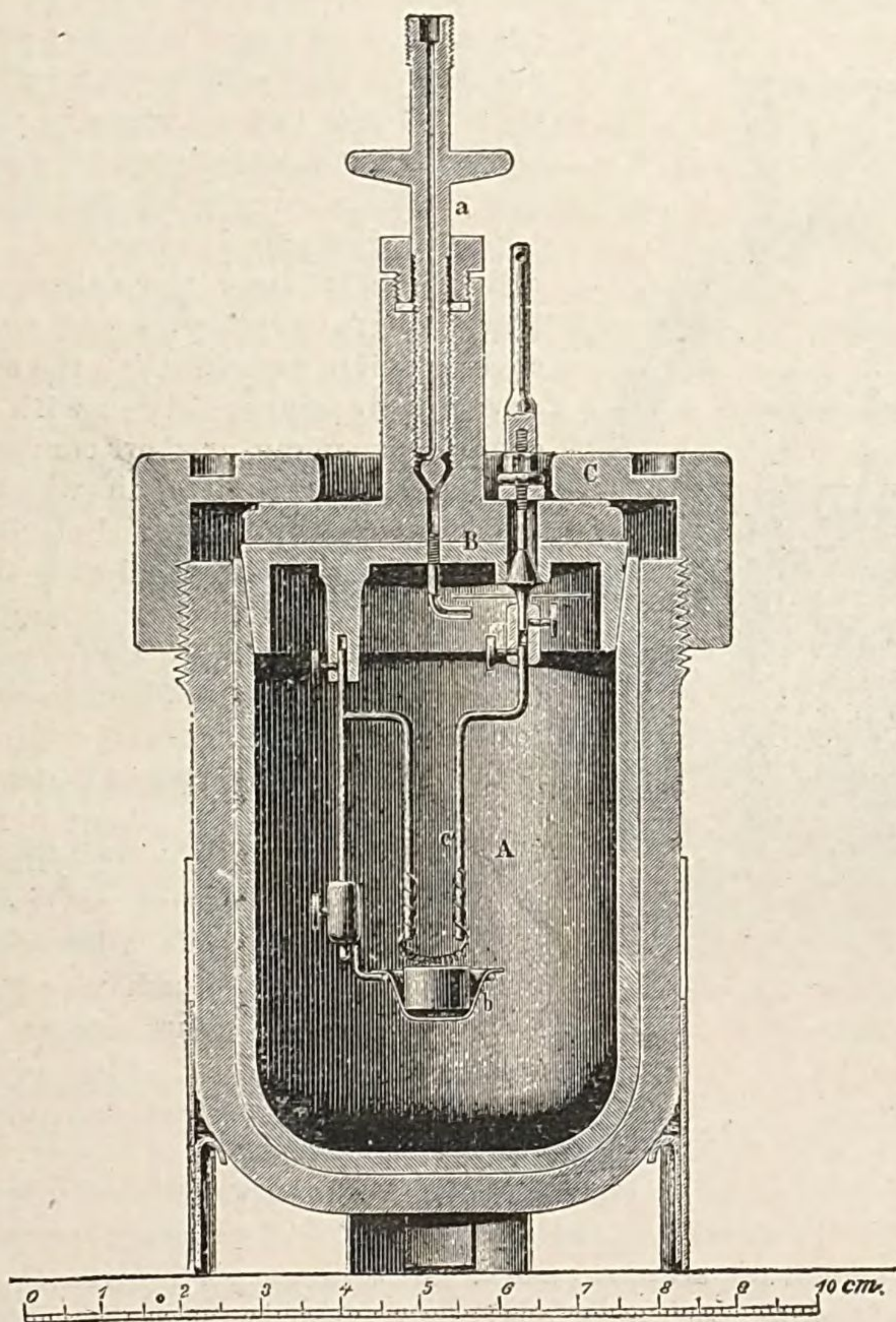


FIG. 11.—Berthelot's bomb calorimeter.

The later and permanent form of Berthelot's bomb is cylindrical with a rounded bottom and flat cover. It is made of steel with a heavy lining of platinum. The size may vary. In the one made by Golaz for Stohmann the diameter is approximately 10 centimeters and the height to the upper surface of the cover about 13 centimeters;

¹Ann. Chim. et Phys. (6), 6, 546.

²In 1885. The principle was discovered and investigated by Frankland in 1864 and 1868. See investigations by him "On the combustion of iron in compressed oxygen." Jour. Chem. Soc., II, 1864; 52. "On the combustion of gases under pressure. Brit. Assoc. Rep. XXXVIII, 1868 (*Sect.*); 37. "On the combustion of hydrogen and carbonic oxid in oxygen under great pressure." Proc. Roy. Soc., XVI, 1868; 419.

the walls are somewhat over a centimeter in thickness. It contains 2,717 grams of steel and 1,233.3 grams of platinum. The internal capacity is about 300 cubic centimeters and it holds, under a pressure of 24 atmospheres, 7 liters, or, in round numbers, 10 grams, of oxygen. The cover fits into the top of the cylinder after the manner of a stopper. It is pressed in and held very tightly by an outer cap or collar which screws on to the outside of the cylinder at the top. The fittings have to be made with the greatest care in order to prevent the escape of gas. The material to be burned is shaped into a small cake by means of a powerful press and is held in a platinum capsule. This capsule is sustained by a platinum wire which is fastened to the under side of the cover. Another platinum wire passes through the cover, from which it is insulated by gutta percha, or other appropriate material. These two

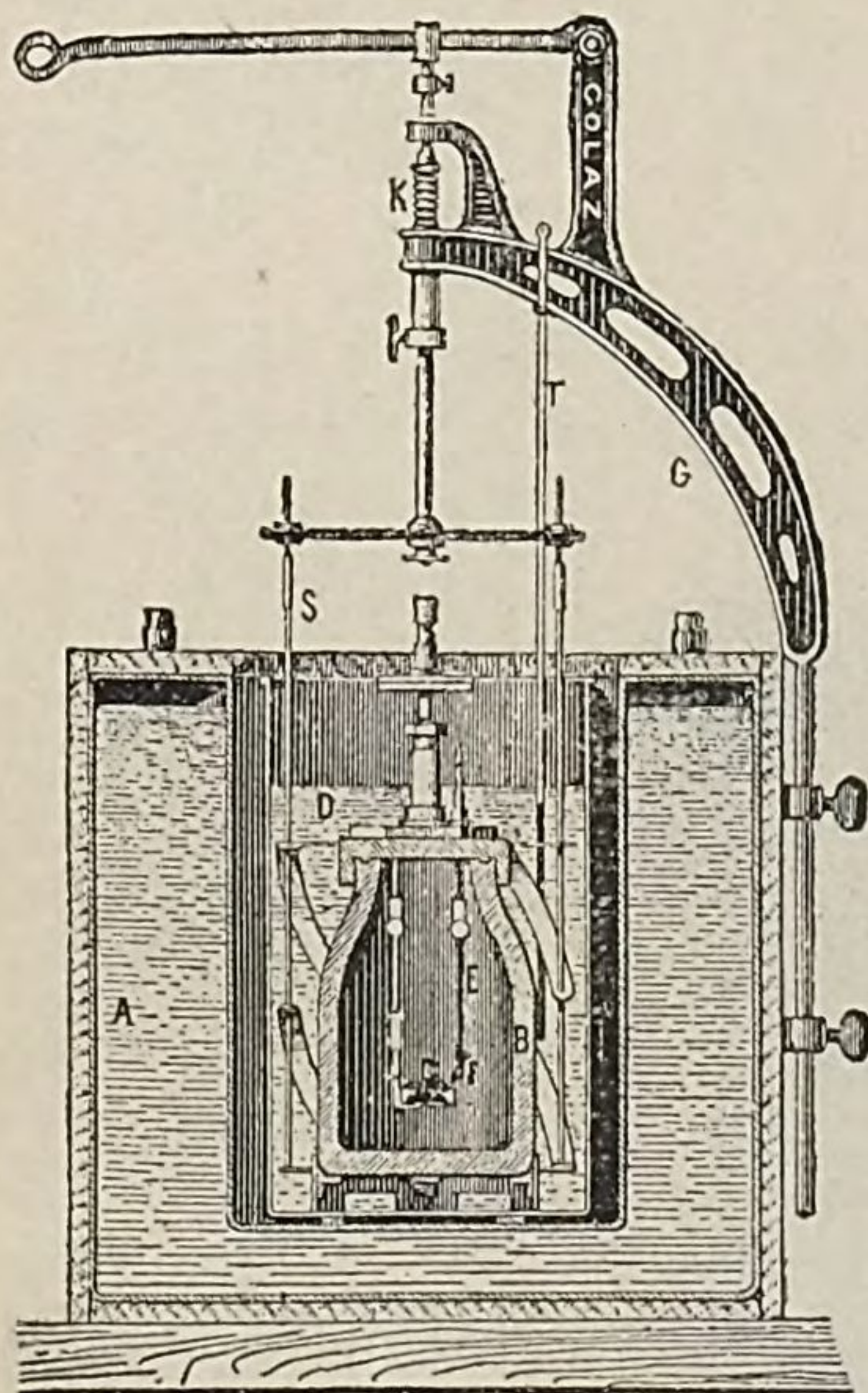


FIG. 12.—Mahler's bomb calorimeter as mounted for use.

wires are so arranged that they are easily connected by a piece of fine iron wire hanging over the substance to be burned in the platinum capsule. An electric current passed through the platinum wire heats the iron wire to a temperature where it burns in the oxygen and, melting, falls upon the substance so as to ignite it. An arrangement at the top of the cover provides for admitting the oxygen. The oxygen is introduced either with the aid of a compression pump, or, more conveniently, from iron or steel cylinders, in which it is held under sufficient pressure. Both Berthelot and Stohmann use such cylinders without the aid of a pump. Experience has shown that it is desirable to have fully three times as much oxygen present as is theoretically necessary for the combustion.

The quantity of water in which the bomb is immersed is generally about 2 liters. It is contained in a calorimeter cylinder of brass or other metal. A stirrer, not easily described without a diagram, plays between the bomb and the cylinder in such way as readily to mix the water and insure uniform temperature after the combustion. The outer cylinders

which are employed by Berthelot and Stohmann to protect the apparatus from gain or loss by heat outside, as above described, are made of copper. It is found that 2 concentric cylinders so arranged as to hold a layer of water between them, the inner being large enough to leave a considerable air space around the calorimeter cylinder, suffice for accurate work. In Stohmann's laboratory the arrangements to insure accuracy are quite elaborate. The work is done in a basement room surrounded by very thick walls of stone. Special devices are employed to keep the temperature of the room exactly constant. The stirrer is moved by a small motor, which is so regulated as to make the movement the same for all determinations. Berthelot uses a motor for the stirring, but conducts the combustions in the laboratory rooms where other work is done and without special arrangements to insure uniform temperature.

The Berthelot bomb calorimeter serves its purpose admirably. It is comparatively simple, easily handled, and does not get out of order when properly cared for. Practically all kinds of ordinary organic compounds are completely oxidized when the proper excess of oxygen is used at an initial pressure of 25 atmospheres. With an accurate thermometer the rise in temperature of the water is measured with great accuracy. The corrections, of which the chief is the thermal water equivalent of

the apparatus, are not particularly difficult to determine. The skill and care required in the manipulation are not beyond any thoroughly expert operator, and the results are very satisfactory indeed, as may be seen by comparing those obtained by Berthelot and Stohmann in determining the heats of combustion of the same material in their respective laboratories.

The only drawback to the Berthelot bomb is the expense, as said above. This is due mainly to the amount of platinum used for the lining. The steel of which the bomb is made is especially exposed to corrosion. Berthelot protects the outside of the bomb by plating with nickel, which serves the purpose very well, as water and air are practically the only corrosive agents to which it is exposed. But with the interior the case is very different. The oxygen at high pressure is very active in itself. The carbon, sulphur, and phosphorus of the substances burned are completely oxidized, and carbonic, sulphuric, and phosphoric acids are formed. Indeed, Berthelot has shown that the apparatus may be used for determining carbon, sulphur, and phosphorus in these forms. More or less of the free nitrogen which is mingled with the oxygen used in the combustion is oxidized and forms nitric acid. It is necessary that the inner surface be covered with some substance which will resist these acids as well as the oxygen. Such materials are easily found, but the practical difficulty has been to find an inexpensive lining which will insure permanent protection to the steel. In Berthelot's first bomb, electroplating with platinum was tried, but the platinum soon began to scale off. After a few combustions gold was substituted for platinum and with better success, but it has not been used with oxygen under pressure.

MODIFICATIONS OF THE BOMB CALORIMETER BY MAHLER, HEMPEL, AND ATWATER.

Various modifications of Berthelot's apparatus have been devised especially to obviate the difficulty of expensive lining.

Mahler uses a bomb (fig. 12) of forged steel with enamel lining.¹ The cylinder is somewhat narrowed at the top and the cover is screwed directly upon it, the junction being made tight by a washer of lead. The enamel is easily put on or replaced, and it is stated that a single coating has been used for 300 combustions without injury. I have understood, however, that the enamel is apt to scale off in constant use. The form described by Mahler has an internal capacity of 600 cubic centimeters or nearly double that of Berthelot's bomb, as above described.

Hempel uses, for determinations of heats of combustion of coal, a simple bomb of steel without lining. This suffices for technical purposes, but is not recommended by him for scientific use.²

In accordance with suggestions by the author, Professor Hempel has most courteously had a bomb made by the mechanic who makes the bombs of his devising, and lined by Heraeus, of Hanau, with a thin sheet of platinum. The principle is the same as in Berthelot's form; but, whereas Berthelot's cover fits into the cylinder in the manner of a stopper, the cover in this rests directly upon the upper edge of the cylinder, a projection of the latter fitting into a groove in the former.

¹ Compt. rend., 113, 774, and 862, and Génie Civil, 1891, 20, No. 12, 198. See also Ztschr. analyt. Chem., 1893, 79, and Berthelot, Calorimétrie Chimique, 133.

² Hempel, Gasanalytische Methoden, 1890, 355. See also English translation; Methods of Gas Analysis, published by McMillan, New York.

A washer of lead is set in the groove of the cover and makes perfect closure feasible. The form of the apparatus is essentially the same as that shown in fig. 13. The quantity of platinum required is small, and the cost of the whole apparatus, including vise grip and lever for screwing the outer cover, a cylinder with compressed oxygen, fittings, manometer, and screw press for making hard pellets of the substance

to be burned, was less than \$220. It has served a most excellent purpose in our laboratory. Mr. C. D. Woods, who has done considerable work with it, has obtained results agreeing very closely with those of Berthelot and Stohmann.

For measuring the temperature of the water, we use a thermometer made by Fuess and calibrated by the Physikalisch-technische Reichsanstalt in Berlin. It is graduated to hundredths of a degree, and the divisions are of such length as to permit easy estimation to thousandths by the aid of a magnifying glass. We are persuaded that in this way measurement of the temperature of water to thousandths of a degree can be made with as close an approach to accuracy as the weighings to the tenth of a milligram with an ordinary laboratory balance.

In place of copper for the cylinders outside the calorimeter cylinder, we have used vessels of "indurated fiber," which is a good nonconductor of heat. They have proved very satisfactory.

The bomb just described has not been found in every way satisfactory. It has, furthermore, seemed desirable to attempt to find a cheaper lining than platinum. Efforts are being made by the writer and his associate, Mr. Woods, to devise some needed improvements, find a less expensive lining than platinum, and develop an effective apparatus which may be made in this

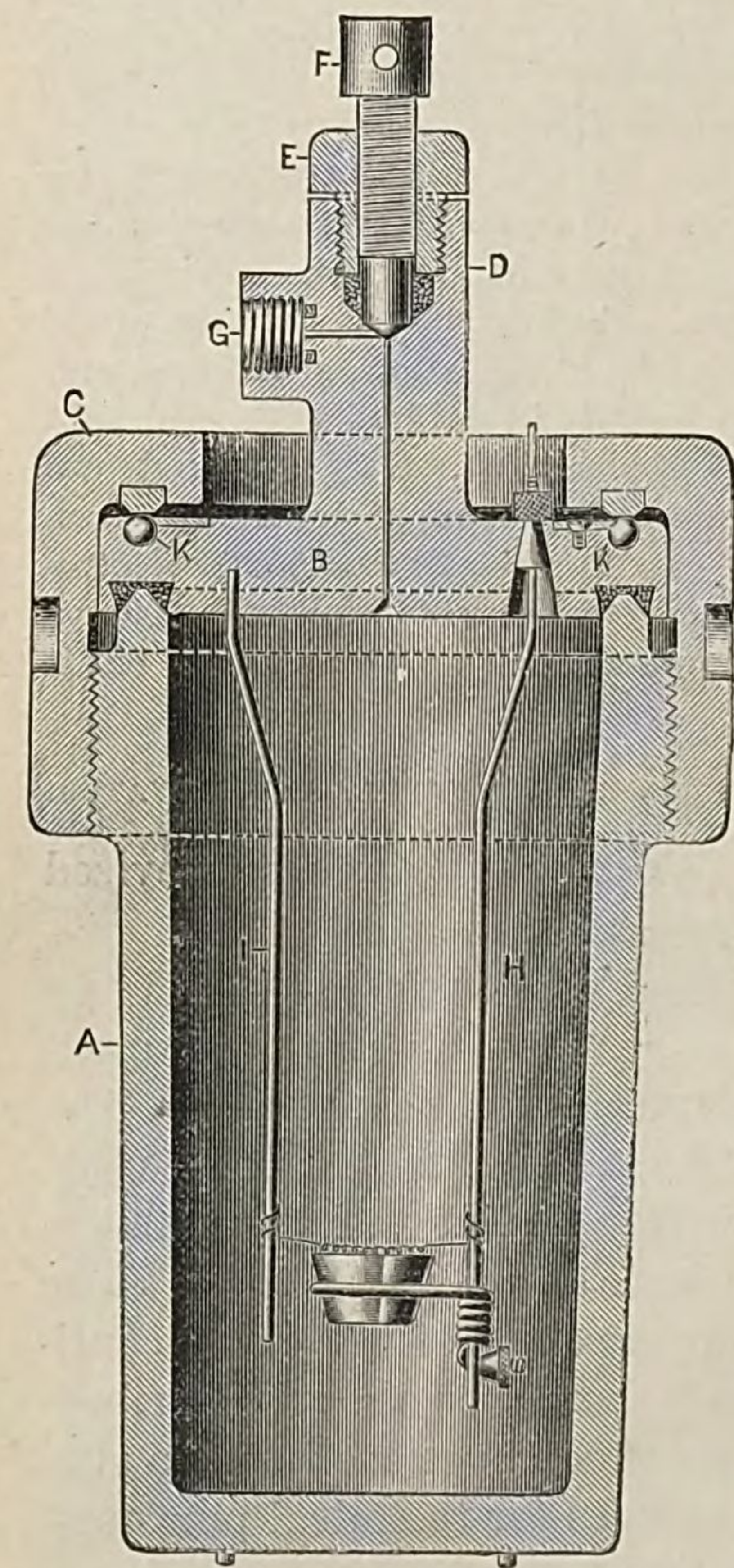


FIG. 13.—Bomb calorimeter as modified by Hempel and Atwater.

country at a cost that will bring it within the reach of ordinary laboratories. The results of these attempts are very encouraging, but are not yet ready for publication.

Figure 13, herewith, will help to explain the apparatus in the form in which we are using it. A represents the cylinder, C the screw cap, and B the cover of the bomb, which is placed upon the top of the cylinder and held down by the screw cap. A and C are made of gun steel. In a bomb lately made by the Pratt & Whitney Company, of Hartford, Conn., the steel is the same as is used for the Hotchkiss guns which are being manufactured by them. The metal has an unusually high tenacity and seems especially well fitted for the purpose. The cover (B) is provided with a neck into which fits a cylindrical screw (E), holding another screw (F). On the side of the neck is an aperture (G) between the lower end of D and the shoulder. In

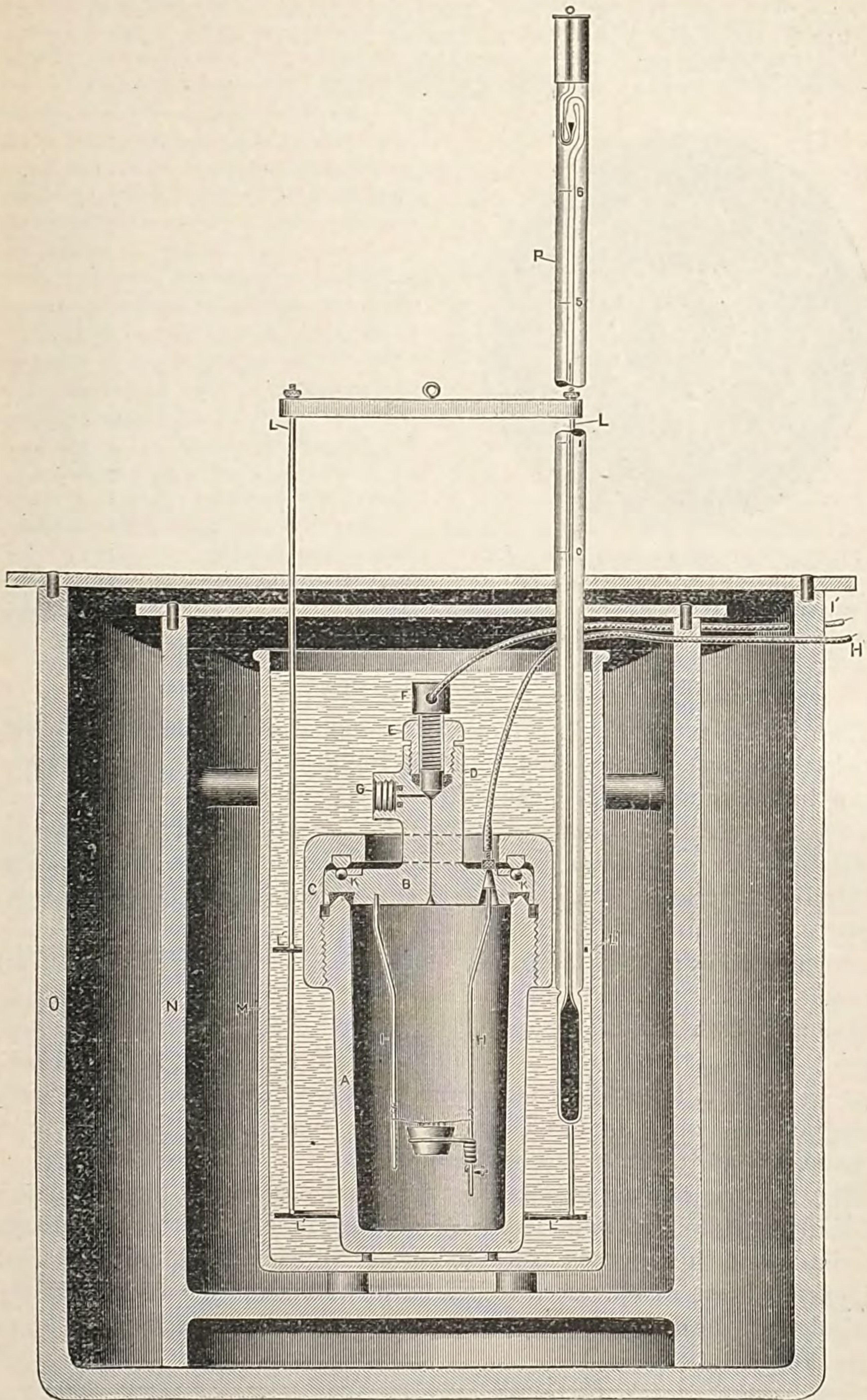


FIG. 14.—Bomb calorimeter of fig. 13, as mounted and standing in water.

D is a washer of lead on which the lower edge of E fits. By opening or closing the screw F the narrow passage from G is opened or closed. The opening is used for admitting oxygen at a high pressure through a narrow passage to charge the bomb. In B is an aperture through which passes a platinum wire (H), which is separated from the metal of the cover by insulating material. Hard vulcanized rubber serves very

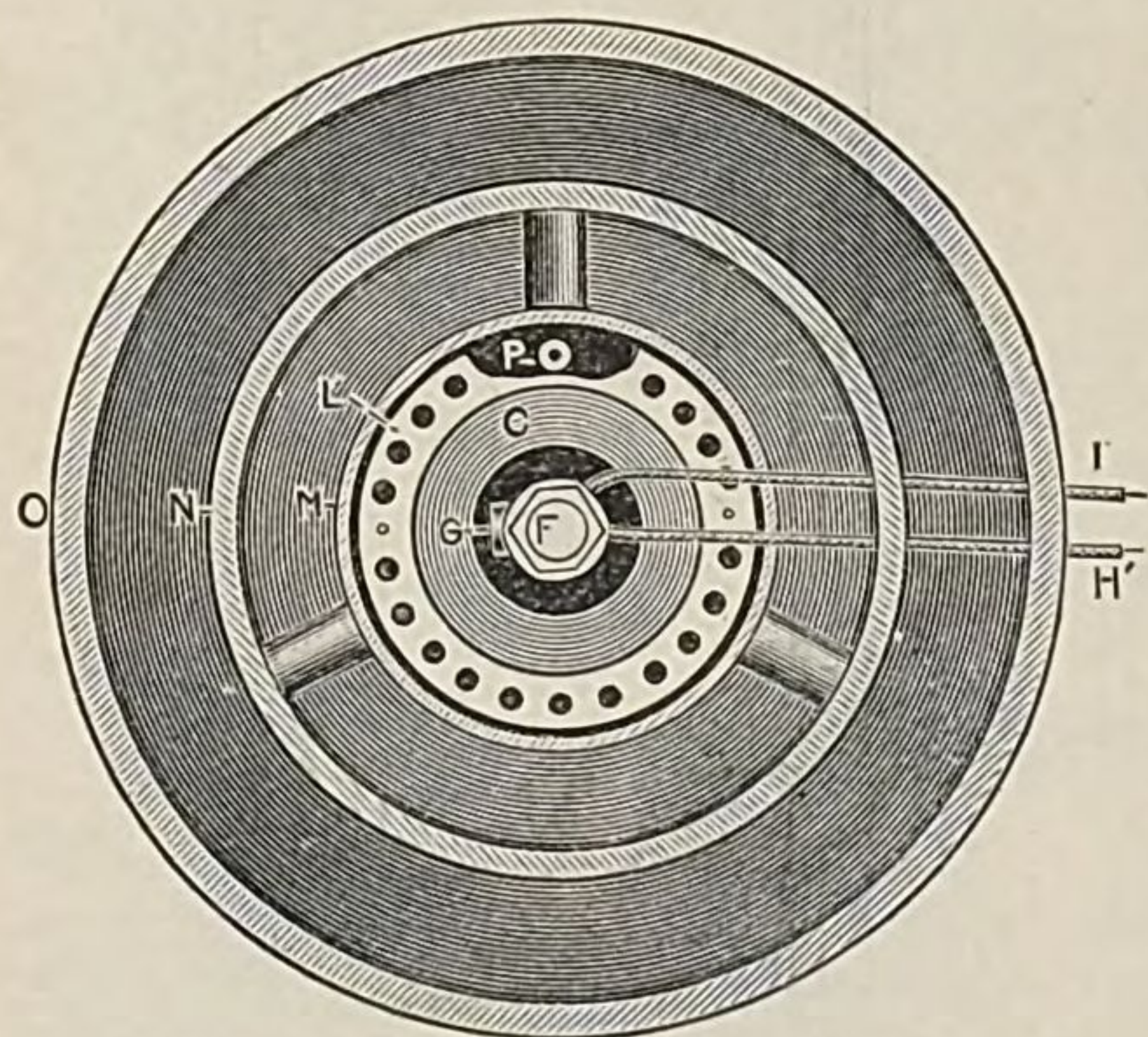


FIG. 15.—Top of bomb calorimeter of fig. 13.

situation of the thermometer (P) is likewise shown. Wires (H' I') serve for bringing the electrical current to the platinum wires in the bomb.

well for this purpose. Fastened to the lower side of the cover is another platinum rod (I), between which and H an electrical connection is made by a very fine iron wire. A screw ring holds the small platinum capsule, in which the substance to be burned is placed. At K K are ball bearings of hard steel to avoid friction in screwing the cap down.

Fig. 14 shows the bomb as mounted and standing in the water, which is contained in the calorimeter cylinder. The large cylinders (N and O) are made of indurated fiber and covered with plates of vulcanized rubber. A stirrer (L) serves for equalizing the temperature of the different portions of water after the combustion is completed. The

RESULTS OF DETERMINATIONS OF HEATS OF COMBUSTION.

The investigations by Frankland in 1866, above cited, like a great deal of the best pioneer work, were of the highest value for their purpose, but have not the accuracy which the later refinements of method have made possible. Determinations of the heats of combustions of a large number of substances by the Thompson-Stohmann method were made by Stohmann and his pupils, Von Rechenberg and B. Danilewski, between 1877 and 1885. Those of a smaller number were made by Rubner in 1885, and by Gibson in 1890, before the method of Berthelot became well known. The greater convenience, rapidity, and accuracy obtainable by use of compressed oxygen with the apparatus of Berthelot, the first description of which was published in 1885, led Stohmann, in 1887, to adopt this method. Since that time he has, with Langbein, not only reviewed his previous results, but added a large number of new ones by this method.

The following table summarizes the results obtained by use of the Thompson-Stohmann and Berthelot methods in determining the heats of combustion of the organic substances which occur in animals and plants, and are of special interest in physiological chemistry. They included all the determinations of this class which we have found up to July, 1894:

¹ Since the above was written an extremely valuable article upon the subject by Professor Stohmann has appeared. See *Experiment Station Record*, vol. 6, and *Ztschr. Biol.*, 31, 364.

Heats of combustion of organic substances.

	Berthelot method.		Thompson-Stohmann method.			
	Berthelot and associates.	Stohmann and Langbein.	Stohmann and associates. ¹	B. Danilewski. ²	Rubner. ³	Gibson. ⁴
ALBUMINOIDS, ETC.						
Gluten.....	55,990.3	.....	.....	6,141	.....	.....
Elastin.....	.....	65,961.3	.....	.....	.....	.....
Plant fibrin.....	55,832.3	65,941.6	.....	6,231	.....	.....
Serum albumin.....	.....	65,917.8	.....	.....	.....	.....
Syntonin.....	.....	65,907.8	.....	.....	.....	.....
Hemoglobin.....	55,910	65,885.1	.....	.....	5,950	.....
Milk casein.....	55,626.4	65,867	5,717	5,785	.....	.....
Do.....	.....	65,849.6	.....	.....	.....	.....
Yolk of egg.....	8,112.4	65,840.9	.....	.....	.....	.....
Legumin.....	.....	65,793.1	.....	5,573	.....	.....
Vitellin.....	55,780.6	65,745.1	.....	.....	.....	.....
Egg albumin.....	55,687.4	65,735.2	5,579	.....	.....	.....
Muscle, extractives and fat removed.....	55,728.4	65,720.5	.....	.....	5,778	.....
Crystallized albumin.....	.....	65,672	5,598	.....	.....	.....
Muscle, fat removed.....	.....	65,662.6	5,324	.....	5,656	.....
Do.....	.....	65,640.9	.....	.....	.....	.....
Blood fibrin.....	55,529.1	65,637.1	5,511	5,709	.....	.....
Harnack's albumen.....	.....	65,553	.....	.....	.....	.....
Wool.....	55,564.2	65,510.2	.....	.....	.....	.....
Conglutin.....	.....	65,479	5,362	.....	.....	.....
Fibrin of skin.....	.....	65,355.1	.....	.....	.....	.....
Peptone.....	.....	65,298.8	.....	5,069	.....	.....
Fish glue.....	55,240.1	.....	.....	5,493	.....	.....
Chondrin.....	55,342.4	65,130.6	.....	4,909	.....	.....
Ossein.....	55,410.4	65,039.9	.....	.....	.....	.....
Fibroin.....	55,095.7	64,979.6	.....	.....	.....	.....
Chitin.....	54,655	64,650.3	.....	.....	.....	.....
Tunicin.....	54,146.8	.....	.....	.....	.....	.....
Paraglobulin.....	.....	.....	5,637	.....	.....	.....
AMIDS, ETC.						
Urea.....	72,530.1	62,541.9	2,465	2,537	2,523	.....
Glycocoll.....	83,133.6	63,129.1	3,053	.....	.....	.....
Alanin.....	84,370.7	64,355.5	.....	.....	.....	.....
Leucin.....	86,536.5	66,525.1	.....	.....	.....	.....
Sarkosin.....	.....	64,505.9	.....	.....	.....	.....
Hippuric acid.....	85,659.3	65,668.2	5,642	.....	.....	.....
Aspartic acid.....	82,911.1	62,899	.....	.....	.....	.....
Tyrosin.....	85,915.9	.....	.....	.....	.....	.....
Asparagin.....	83,396.8	63,514	3,428	.....	.....	.....
Kreatin (cryst).....	.....	63,714.1	.....	9 (3,206)	.....	.....
Kreatin (water-free).....	.....	64,275.4	.....	.....	.....	.....
Uric acid.....	10 2,754	62,749.9	2,621	.....	.....	.....
Guanin.....	.....	63,891.7	.....	.....	.....	.....
Caffein.....	.....	65,231.4	.....	.....	.....	.....
FATS.						
1. Animal:	.....	.....	.....	.....	.....	.....
Fat of swine.....	.....	11 9,476.9	9,380	12 9,686	9,423	9,515
Fat of oxen.....	.....	11 9,485.7	9,357	.....	.....	9,427
Fat of sheep.....	.....	11 9,493.6	9,406	.....	.....	9,530
Fat of horse.....	.....	.....	9,410	.....	.....	.....
Fat of dog.....	.....	.....	9,330	.....	.....	.....
Fat of goose.....	.....	.....	9,345	.....	.....	.....
Fat of duck.....	.....	.....	9,324	.....	.....	.....
Fat of man.....	.....	.....	9,398	.....	.....	.....
Butter fat.....	.....	11 9,215.8	9,192	.....	.....	9,185
Sperm oil.....	.....	.....	.....	.....	.....	10,001

¹ Jour. prak. Chem., 139 (N. F., 31), 273. These results were published in detail in Landw. Jahrb., XIII (1884), 413; later the figures were slightly changed as a result of the determination of the experimental corrections of the method and appear (corrected) as cited above (Jour. prak. Chem.).

² Centbl. med. Wiss., 1881, Nos. 26 and 27. Ref. Jahresb. Thier-Chem., 11 (1881), 7.

³ Ztschr. Biol., 21 (1885), 250.

⁴ Report of Storrs (Conn.) Experiment Station, 1890, 182.

⁵ Ann. Chim. et Phys. (6), 22, 25.

⁶ Jour. prak. Chem., 152 (N. F., 44), 1891, 336.

⁷ Ann. Chim. et Phys. (6), 20, 13.

⁸ Ibid. (6), 22, 1.

⁹ Extract of meat.

¹⁰ Compt. rend., 110, 1267.

¹¹ Jour. prak. Chem., 150 (N. F., 42), 1890, 361.

¹² Kind of fat not specified.

Heats of combustion of organic substances—Continued.

	Berthelot method.		Thompson-Stohmann method.			
	Berthelot and associates.	Stohmann and Langbein.	Stohmann and associates. ¹	B. Danilewski. ²	Rubner. ³	Gibson. ⁴
FATS—continued.						
2. Vegetable:						
Olive oil (expressed)			9,328			9,471
Do			9,471			
Peppy-seed oil (expressed)			9,442			
Rape-seed oil (expressed)			9,489			
Do			9,619			
Ether extract of various seeds			{ 9,130 }			
			{ 9,467 }			
CARBOHYDRATES, ETC.						
1. Pentoses:						
Arabinose	53,714	63,722	3,695			
Xylose	53,739.9	63,746				
Fucose		64,340.9				
Rhamnose (water-free)		64,379.3				
Rhamnose (cryst)		63,909.2				
2. Hexoses:						
Sorbinose		63,714.5				
Galactose		63,721.5	3,659			
Dextrose		63,742.6	3,692			3,754
Fructose	73,762	63,755				
3. Heptoses:						
Glucoheptose	83,732.8					
4. Disaccharids:						
Cane sugar	93,961.7	63,955.2	3,866		4,001	3,921
Milk sugar		63,951.5	3,877			
Milk sugar (cryst)	93,777.1	63,736.8	3,663			3,710
Maltose		63,949.3				
Maltose (cryst)		63,721.8				
Trehalose		63,947				
Trehalose (cryst)		63,550.3				
5. Trisaccharids:						
Meletriase	54,020	64,020.8				
Meletriase (cryst)		63,400.2				
Melezitose		63,913.7				
6. Polysaccharids:						
Glycogen		4,190.6				
Cellulose	104,200	64,185.4	4,146			
Starch	94,228	64,182.5	4,123			4,164
Dextran	94,180.4	64,112.3				
Inulin	94,187.1	64,133.5	4,070			
ALCOHOLS.						
Ethyl alcohol	117,068					
Glycerin		124,112.4	4,317			
Mannite	94,001.2	63,997.8	3,908			3,959
Inosite	53,676.8	63,679.6				
ACIDS.						
Acetic	113,490.4					
Palmitic		139,352.9	9,226			
Stearic			9,423			
Oleic		139,494.9				
Malonic	141,998.2		1,960			
Succinic	143,006.2		3,019			
Tartaric			1,745			
Citric	142,477.9		2,397			

¹ Jour. prak. Chem., 139 (N. F., 31), 273. These results were published in detail in Landw. Jahrb. XIII (1884), 413; later the figures were slightly changed as a result of the determination of the experimental corrections of the method and appear (corrected) as cited above (Jour. prak. Chem.).

² Centbl. med. Wiss., 1881, Nos. 26 and 27. Ref. Jahresb. Thier-Chem., 11 (1881), 7.

³ Ztschr. Biol., 21 (1885), 250.

⁴ Report of Storrs (Conn.) Experiment Station, 1890, 182.

⁵ Ann. Chim. et Phys. (6), 21, 409.

⁶ Jour. prak. Chem., 153 (N. F., 45), 305, and private communication from Professor Stohmann.

⁷ Ann. Chim. et Phys. (6), 13, 304.

⁸ Compt. rend., 114, 921.

⁹ Ann. Chim. et Phys. (6), 10, 455.

¹⁰ Ibid. (6), 6, 546.

¹¹ Ibid. (6), 27, 310.

¹² Jour. prak. Chem. 150 (N. F., 42), 1890, 361.

¹³ Ztschr. physikal. Chem., 10, 1892, 410.

¹⁴ Ann. Chim. et Phys. (6), 23, 179.

NOTE.—The most of Berthelot's work is also referred to by Stohmann under references ⁵⁻¹⁵. Under reference ¹⁵ will be found a table summarizing all of Stohmann's work with the bomb and some of the results obtained by Berthelot and his associates.

INVESTIGATIONS OF HEATS OF COMBUSTION NOW NEEDED.

This field of inquiry is new and offers most excellent opportunity for useful work. The directions in which inquiry are now most needed are practically two—the study of compounds of interest in physiological chemistry and the study of the foods and feeding stuffs in which those compounds occur. In addition to the materials which are used in the nutrition of animals and plants the excretory products, which contain undigested residues and cleavage products from them, also demand investigation.

Heats of combustion of organic compounds.—The determination of heats of combustion of compounds of interest in physiological chemistry is desirable for two purposes, (1) for obtaining better knowledge of their chemical constitution, and (2) for securing the much-needed information as to their physiological uses, and especially their fuel values.

The indications which the heats of combustion give regarding the molecular constitution is of the greatest importance in the present condition of chemical science; and, aside from the purely theoretical interest of the inquiry there are various practical applications of value to the chemist; as, for instance, in distinguishing between isomeric compounds.

The importance of the measurements of fuel value of the compounds has already been indicated and hardly needs to be insisted upon further in this place.

The compounds which most demand study are of the kinds already studied and reported upon in the statements above. It is safe to say that all of the organic constituents of animal and vegetable tissues and their cleavage products, especially such as are formed by metabolism and living organisms, demand extended study; and it is of course desirable that the determinations of the heats of combustion should accompany and be supplementary to the investigation of their general characters, chemical and physical. In many laboratories these compounds are being isolated and studied. It is extremely desirable that the heats of combustion be determined at the same time.

What we need to do is to secure the materials in as large variety and of as great purity as possible and burn them in the calorimeter with due precaution, and record the results. If a number of investigators will undertake a research of this kind, the needed information will gradually accumulate.

Heats of combustion of foods and feeding stuffs, etc.—But the materials in which the compounds occur likewise demand calorimetric investigation. We may take, for instance, a food material, as wheat flour, study its composition, isolate its several constituents, and determine the potential energy of each, but at the same time it is desirable to burn the flour and observe whether its energy, as thus directly determined, corresponds with the energy as learned from the combustion of the several constituents. Investigations of this kind bring out discrepancies

between the results obtained by combustion of the material as a whole and by separating the several ingredients and determining their heats of combustion and thus estimating the heat of combustion of the whole material. It is only by careful comparative studies of this kind that we shall learn the reasons for the discrepancies, the sources of error, and means for avoiding them, and the correct methods for determining the fuel values of food materials.

Although the work thus far done gives most cheering prospects of ultimate success, the results are not yet ripe for publication.

ISODYNAMIC VALUES OF NUTRIENTS.

It has been assumed that the heats of combustion of the several ingredients of food represent the potential energy which is transformed into kinetic energy when the food is used in nutrition. This principle may be expressed otherwise in saying that in their services as fuel to yield heat and mechanical (muscular) power their values will be directly proportional to the amounts of potential energy they contain. If this be true, we should expect that they would replace one another in proportion to their several heats of combustion. Late experiments, notably those of Rubner, imply that this is actually the case. A proper discussion of this subject will require the consideration of a large amount of detail. Reserving that for another occasion, I quote here a short popular description of experiments by Rubner which were made some ten years ago.¹

Within a short time past, feeding trials with animals in the respiration apparatus have shown the proportions in which the several classes of nutritive ingredients of food do one another's work in serving as fuel in the body, and more extended experiments, with improved forms of the calorimeter, have given very accurate measurements of the amounts of potential energy in the same materials. The respiration experiments have been made with dogs, in the Physiological Institute in Munich, by Dr. Rubner, who has also made an extended series with the calorimeter. The largest number of the experiments with food materials in the calorimeter, however, have been conducted by Professor Stohmann, of the University of Leipsic, and his assistants. The results of experiments with the respiration apparatus and with the calorimeter agree with most remarkable closeness. In supplying the body with fuel, the protein, fats, and carbohydrates replaced each other in almost exact proportion to their heats of combustion. That the living body should thus be proved to use its food with such perfect chemical economy is certainly interesting and important. It is one more fact to add to the long lists that are bringing the functions of life more and more within the domain of ordinary physical and chemical law.

Isodynamic values for 100 parts of fat.

Nutritive substances, water free.	As determined by direct experiments with animals.	As determined by calorimeter.
Myosin.....	225	213
Lean meat.....	243	235
Starch.....	232	229
Cane sugar.....	234	235
Grape sugar.....	256	255

¹ Century Magazine, July, 1887.

The quantities of the several substances, lean meat, myosin (the chief protein compound of lean meat), starch, etc., are those which were found to yield the same amounts of heat when burned in the calorimeter, or to render the same service as fuel when consumed in the body of the animal, as 100 grams of fat. This explanation of the meaning of the expression "isodynamic values for 100 parts of fat" needs a little qualification to make it perfectly correct, but it is as accurate as I can well make it without going into a discussion too abstruse for the pages of a magazine, and it is really accurate enough for our purpose. The figures mean, then, that the dogs in the respiration apparatus obtained, on the average, as much heat to keep their bodies warm and energy for the work their muscles had to do, from 243 grams of lean meat) i. e., meat enough to furnish 243 grams of nutritive material after the water had been driven out), as they obtained from 100 grams of fat, while 235 grams of the lean meat, burned to equivalent products in the calorimeter, would yield the same amount of heat as the 100 grams of fat. Considering the great difficulties in experimenting with live animals, these two isodynamic values, 243 by the respiration apparatus and 235 by the calorimeter, agree very closely indeed. But with starch, the results by the two methods, 232 and 229, are still closer, while with ordinary table sugar and grape sugar they are as good as identical.

Taking our ordinary food materials as they come, and leaving out slight differences, due to the differences in digestibility, etc., Dr. Rubner has made the following general estimate of the amounts of energy in 1 gram of each of the three principal classes of nutrients:

Potential energy in nutrients of food.

	Calories.	Foot-tons.
In one gram of protein.....	4.1	6.3
In one gram of fats.....	9.3	14.2
In one gram of carbohydrates.....	4.1	6.3

These figures mean that when a gram (one-twentieth of an ounce) of fat, be it the fat of the food or body fat, is consumed in the body, it will, if its potential energy be all transformed into heat, yield enough to warm a kilogram of water 9.3 degrees of the centigrade thermometer, or, if it be transformed into mechanical energy such as the steam engine or the muscles use to do their work, it will furnish as much as would raise 1 ton 14.2 feet or 14.2 tons 1 foot. A gram of protein or carbohydrates would yield a little less than half as much energy as a gram of fat. In other words, when we compare the nutrients in respect to their fuel values, their capacities for yielding heat and mechanical power, an ounce of protein of lean meat or albumen of egg is just about equivalent to an ounce of sugar or starch; and a little over 2 ounces of either would be required to equal an ounce of the fat of meat or butter or body fat. The potential energy in the ounce of protein or carbohydrates would, if transformed into heat, suffice to raise the temperature of 113 pounds of water 1° F., while an ounce of fat, if completely burned in the body or in the calorimeter, would yield as much heat as would warm over twice that weight of water 1 degree.

One principle which they bring into clear relief is the remarkable economy with which the animal organism uses its material when the supply is limited, and the positive wastefulness it practices when the food supply exceeds the demand.

The dogs had very little room to move about inside the apparatus, and of course made very little muscular exertion. Hence they needed but little protein to make up for the wear of muscle; and, practically, the main demand of their bodies was for fuel to yield heat to warm their bodies and strength for the very little work their muscles had to do. When they fasted they consumed the fat and protein from the store in their bodies. How rigidly economical they were in this draft upon their previously accumulated capital was shown in the way that the consumption of fuel was affected by the temperature of the room. The interior temperature of the body remained very nearly the same, at "blood heat," all the while, as indeed it must, or

the dogs would have died. In cold days more heat was radiated from the body than in warm, more was needed to supply its place, and more material was consumed. When the room was warmer the body burned less fuel; and the quantities consumed marked the changes of temperature with a delicacy almost comparable with that of the thermometer.

When the dogs had just food enough to supply their needs they used it with similar economy. In other words, when the income was equal to the necessary expenditure it was used as sparingly, as the sums taken from the capital had been. When the food supply was made larger, part of the extra material was stored in the body as fat and protein, but at the same time the daily consumption increased. That is to say, when their income was more liberal they laid part of it by, but at the same time allowed their current expenses to increase. It has been found by numerous experiments that when the nutrients are fed in large excess the body may continue for a time to store away part of the extra material, but after it has accumulated a certain amount it refuses to take on more, and the daily consumption equals the supply even when this involves great waste. With the large income the body continues for a time to add to its capital, but finally it comes to spend as much as it gets, and in so doing practically throws away what it can not profitably use.

Dr. Rubner's dogs showed in still another way their economy of fuel when the supply was limited, and wastefulness when they had more than they needed. The same animal that adjusted its consumption of fuel so accurately to the temperature of the air as long as the amount did not exceed its need, used it with no apparent regard to the temperature, whether warm or cold, as soon as the supply of food exceeded the necessary demand.

Physiologists have observed that the consumption of fuel in the body sometimes varies with the temperature and sometimes does not, and have been at a loss to explain the apparent discrepancies in their experimental results. These experiments help toward an explanation. But the interesting point is, not simply that the facts are learned, but that they are learned by studying the subject from the standpoint of the potential energy of the food. Previously the accounts have, so to speak, been drawn up in terms of protein, carbohydrates, and fats, and the balances have been difficult to calculate and still more difficult to explain. But in the experiments of which I have just been speaking, all the figures were reduced to terms of potential energy of the food and body substance consumed or stored. The results were calculated in calories, and the balancing of the accounts was thus made simple and the explanation plain.

Of course, I do not mean to say that we have thus suddenly come upon a complete explanation of the whole subject. This is simply an improvement of methods based on clearer understanding of principles and leading to clearer and more accurate results. It is, in short, the old story of clearing up an old mystery by use of a new and rational idea. As such, as well as for stronger reasons, it is of interest.

It is so easy to magnify the importance of any new discovery, and so hard to avoid going too far in drawing inferences from it, that I am inclined to put in another word of caution here. For instance, from the experiments above described one would infer that the food ingredients yield strength for muscular labor in exact proportion to their heats of combustion. But the dogs in the respiration apparatus performed no muscular work except that inside their bodies for respiration, keeping the blood in circulation, etc., and though we naturally assume that if they had used their muscles for exterior work, such as running or working a treadmill, the muscular energy yielded by the food would have been likewise equal to its potential energy, and though the other known facts make this assumption entirely probable, the experiments do not absolutely prove it. The production of muscular strength is a problem which is still but partly solved. Still I think it is reasonably safe to say that, in general, the foods that have the most potential energy are the ones that yield, not only the most heat to keep the body warm, but also the most strength for muscular work.

FUEL VALUES OF PROTEIN, FATS, AND CARBOHYDRATES.

The isodynamic values of the nutrients as computed by Rubner are for protein and carbohydrates each 4.1, and for fats 9.3 grams. It is hardly superfluous to repeat that these values are tentative, and that they can not apply with exactness to the nutrients of all food materials. They represent the results of the small number of experiments thus far made. Nearly all of these have been made with dogs, and the number of kinds of food material has been limited mainly to meats, a small number of kinds of fat, and to such carbohydrates as starch and sugar. In the estimates for protein, allowance is made for the nitrogenous material, chiefly urea, which does not undergo complete combustion in the body. The figures are based partly upon direct experiments and partly upon a priori estimates. Doubtless a more critical study of the subject will call for more or less revision of these figures for the fats that have been experimented with, and there is no question that different figures will have to be assigned to the nutrients of the same class from different foods and feeding stuffs. The correct estimates must be found by the same kinds of experimenting as are needed to confirm the theory that the law of conservation of energy actually applies in the living organism. These experiments will, of course, be calorimetric. They will be made in part by determinations of heats of combustion with the bomb calorimeter or other appropriate apparatus, but the chief dependence must be put upon experiments by which accurate determinations are made of the total income and outgo of the animal body as expressed in terms of both matter and energy. The respiration calorimeter is such an apparatus.

RESPIRATION CALORIMETERS.

During the past twelve years a number of efforts have been made to devise an apparatus by which accurate determination could be made of not only the chemical elements and compounds, but also the energy received and given off from the body. The most successful forms of which accounts have been published at all in detail are those of Rubner and Rosenthal. Each of these is essentially a small respiration apparatus, with a device for measuring the heat radiated from the body.

In the apparatus of Rubner¹ the respiration chamber consists essentially of a metal box with double walls. In the interior are arrangements for keeping an animal for a considerable length of time, as in an ordinary respiration apparatus. Provision is made for conducting a current of air through this chamber and for measuring its amount and determining its composition.

The apparatus of Rosenthal² is similar in principle to that of Rubner. The respiration chamber is double walled and the quantity of heat radiated from the animal is estimated by the expansion of the air

¹ Calorimetrische Methodik, Marburg, Elwert, 1891.

² Calorimetrische Untersuchungen, Arch. Anat. Physiol., Physiol. Abth., 1894, 223-282.

inclosed between the two walls. That is to say, in Rubner's apparatus the air, instead of being kept at a constant volume, is allowed to expand or contract, and the quantity of heat which passes through it is estimated from the increase of volume at constant pressure, while in the apparatus of Rosenthal the estimate is made by the variation of pressure at a constant volume. An especially noteworthy feature of the apparatus of Rosenthal is a device by which a definite volume of air is kept continually passing through the chamber. On emerging it passes through absorbents by which the respiratory products are removed, a fresh supply of oxygen being added at the same time, so as to maintain a constant volume. The space between the two walls of the box is filled with air, which is tightly confined so that none can escape. A manometer serves for determining the pressure, which is increased as the temperature rises and decreased as the temperature falls. The larger the amount of heat radiated from the body of the animal the higher will be the temperature, other conditions remaining the same, at which this confined portion of air is maintained, and hence the greater will be the pressure as registered by the manometer. Professor Rosenthal has been at no little pains to explain both the theory and the practice of this method of measuring the radiation of heat. A number of experiments have been made, but they are mostly of a character either special or preliminary, and in those thus far published no complete measurement of the income and outgo of material energy has been given. Rubner's arrangements for measuring and analyzing the air passing through the chamber are the same as those in the small respiration apparatus which was described above as devised by Voit on the principle of the apparatus of Pettenkofer. For full details of Rubner's apparatus as well as of Rosenthal's the original descriptions may be consulted.

RUBNER'S EXPERIMENTS WITH THE RESPIRATION CALORIMETER.

Rubner has lately published¹ the results of a very interesting series of experiments with dogs, in which the metabolism of material has been measured in terms of nitrogen and carbon, and that of energy in terms of the heat of combustion of the food and the heat radiated from the body. The animals were entirely at rest, and there was, therefore, no external work. Under these circumstances it was assumed that all of the energy given off from the body would be in the form of radiated heat. The number of these experiments has been rather small. The published account does not contain the full details. The results are in part estimated rather than directly determined, but, as given, they confirm both the correctness of the figures for isodynamic values of nutrients, which Rubner had previously annexed, and the application of the law of the conservation of energy in the organisms of the animals. The whole results may be summarized in the statement of

¹De Quelle der thierischen Wärme, Ztschr. Biol., 30, 1893, 73.

Rubner to the effect that, considering the animal as a calorimeter, the heats of combustion of the nutrients are found to be the same as when determined by direct combustion with oxygen in the Thompson-Stohman, or bomb calorimeter.

OTHER RESPIRATION CALORIMETERS.

Professor Voit, of Munich, has devised a form of calorimeter for experiments with a man or other animal, but has, so far as I am aware, published no description, and the information which I have gained from brief personal inspection is hardly adequate or appropriate for publication.

Professor Chauveau, of Paris, has devised an apparatus which may be used for experiments with horses or oxen. It was in process of construction in the winter of 1892-93, but I have seen no detailed accounts of experiments made with it and can only refer to it in this very general way.

A small respiration calorimeter, on a plan based upon a principle very similar to that employed by Rosenthal and Rubner, has been lately described by Messrs. Hal-dane, White, and Washbourn.¹ Reference has also been made in print to an apparatus for similar purpose by Professor Burdon-Sanderson,² of Oxford; but I am not aware that any accounts of actual experiments with complete determinations of income and outgo of matter and energy by either of the instruments just named have been published.

An apparatus for similar purpose is now in process of development in the chemical laboratory of Wesleyan University. It is of a size appropriate to experiments with a man.

¹Jour. of Physiol., 16, 1894, 123.

²Phil. Mag. [5], 29, 306.

CHAPTER VIII.

PECUNIARY ECONOMY OF FOOD.

The cost of food is the principal item of the living expenses of the majority of people—of all, indeed, but the especially well-to-do in Connecticut and the other Eastern States.¹ In the report of the Bureau of Statistics of Labor of Massachusetts for 1884 are summarized the results of investigations into the cost of living of people with different incomes in Massachusetts, in Great Britain, and in Germany. Dividing expenses into those for food, clothing, rent, fuel, and sundries, the percentage of the whole income expended for food averages as follows:

Percentage of family income expended for subsistence.

	Annual income.	Expended for food.
		<i>Per cent.</i>
GERMANY.		
Workingmen.....	\$225 to \$300	62
Intermediate class.....	450 to 600	55
In easy circumstances.....	750 to 1,100	50
GREAT BRITAIN.		
Workingmen.....	500	51
MASSACHUSETTS.		
Workingmen.....	350 to 400	64
Do.....	450 to 600	63
Do.....	600 to 750	60
Do.....	750 to 1,200	56
Do.....	Above 1,200	51

The large majority of families in this country are said to have not over \$500 a year to live upon. More than half of this goes, and must go, for food. The cost of preparing food for the table, rent, clothing, and all other expenses must be provided from the remainder.

These statements apply less accurately to farmers than to the inhabitants of the larger towns, but, although the farmer produces much of his food, yet taking everything into account the expense for nutriment is large even for him.

Late statistics published by the United States Department of Labor imply a smaller relative cost of food in the Southern and Western States, where food materials are cheaper, than in the Eastern States. In some cases the expense falls below 50 per cent of the total earnings of wage workers.

Although the cost of food makes so large a part of the whole cost of living, and although the health and strength of all are so intimately connected with and dependent upon their diet, yet even the most intelligent people know less of the actual uses and values of their food for fulfilling its purposes than of almost any other of the necessities of life.

¹ In portions of the West and South, where food is less expensive, its cost is somewhat less in comparison with other living expenses.

CHEAP V. DEAR FOOD.

The cheapest food is that which supplies the most nutriment for the least money. The most economical food is that which is the cheapest and at the same time best adapted to the wants of the user. The maxim that "the best is the cheapest," does not apply to food. The best food, in the sense of that which is the finest in appearance and flavor, and which is sold at the highest price, is not generally the cheapest, nor is it always the most healthful or economical.

Of the different food materials which the market affords, and which are palatable, nutritious, and otherwise fit for nourishment, what ones are peculiarly the most economical? There are various ways of comparing food materials with respect to the relative cheapness or dearthness of their nutritive ingredients. One, and perhaps the best, consists in comparing the nutrients obtained for a given sum in different materials. Table 16, which follows, gives estimates of amounts of nutrients that could be purchased for 25 cents at the rates named. The calculations are based upon the analyses in Table 1 and upon the retail prices current in Connecticut.

The figures of the table tell their story so plainly that they need very little comment. A quarter of a dollar invested in the sirloin of beef at 22 cents per pound pays for $1\frac{1}{7}$ pounds of the meat with three-eighths of a pound of actually nutritive material. This would contain one-sixth of a pound of protein and one-fifth of a pound of fat, and supply 1,120 calories of energy. The same amount of money paid for oysters at the rate of 50 cents per quart brings 2 ounces of actual nutrients, an ounce of protein, and 230 calories of energy. But in buying wheat flour at \$7 a barrel the 25 cents pays for $6\frac{1}{4}$ pounds of nutrients with eight-tenths of a pound of protein and 11,755 calories of energy.

The price of food is not regulated solely by its value for nutriment. Its agreeableness to the palate or to the buyer's fancy makes a large factor of the current demand and market price. There is no more nutriment in an ounce of protein or fat of the tenderloin of beef than in that of the round or shoulder. The protein of animal foods does, however, have an advantage over that of vegetable foods. Animal foods, such as meats, fish, milk, and the like, gratify the palate in ways which most vegetable foods do not, and, what is perhaps of still greater weight in regulating the actual usage of communities by whose demand the prices are regulated, they satisfy a real need by supplying protein and fats, which vegetable foods lack.

People who can afford it, the world over, will have animal foods and will compete with one another in the prices they give for them. In general, the animal foods are more easily and completely digested than vegetable. There is doubtless good ground for paying somewhat more for the same quantity of nutritive material in the animal food.

For persons in good health the foods in which the nutrients are most expensive are like costly articles of adornment. People who can well afford them may be justified in buying them, but they are not economical.

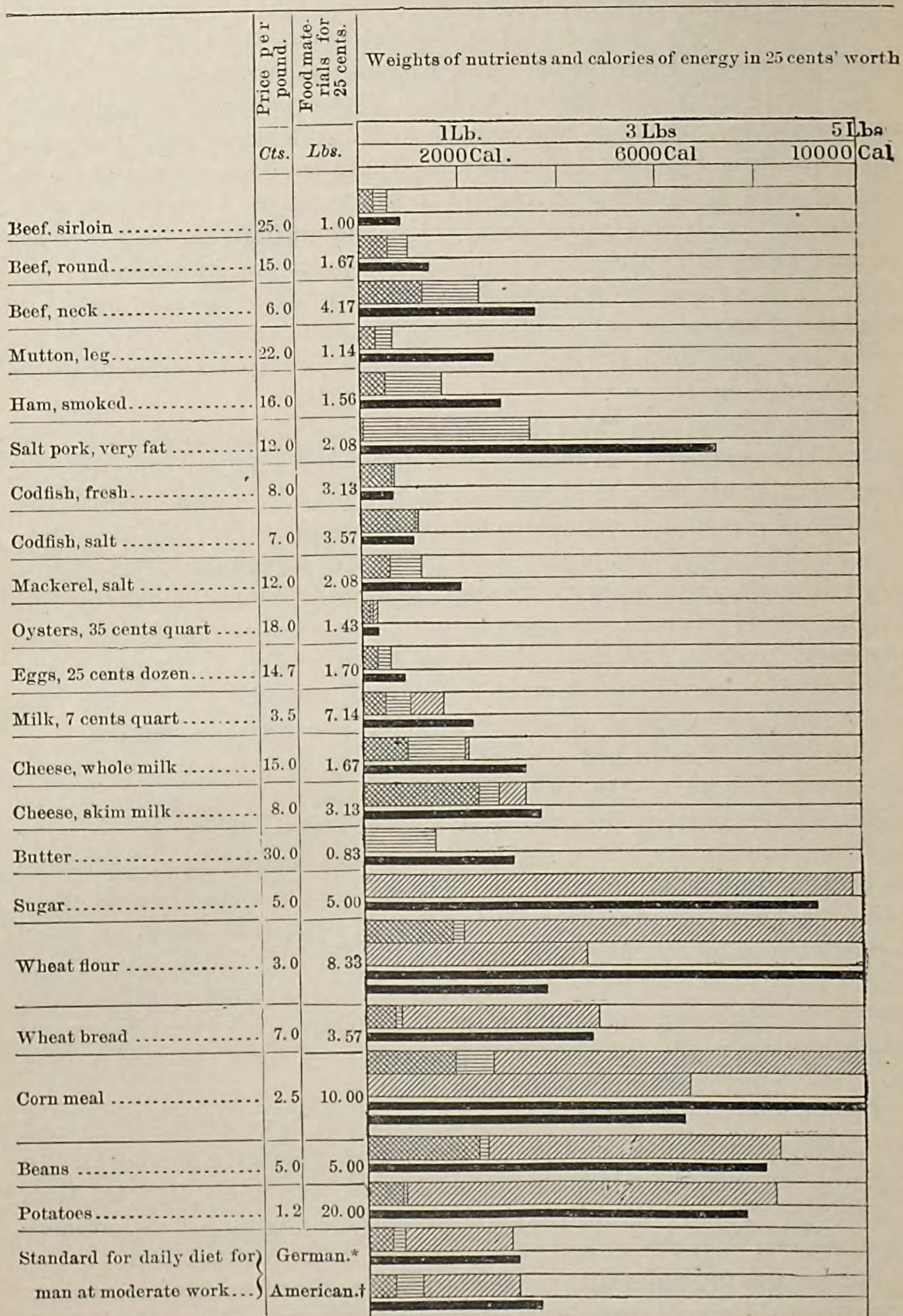
CHART 2.—PECUNIARY ECONOMY OF FOOD.

Amounts of actually nutritive ingredients obtained in different food materials for 25 cents.

[Amounts of nutrients in pounds. Fuel value in calories.]

Protein. Fats. Carbohydrates. Fuel value.



* Voit.

† Atwater.

TABLE 16.—Amounts of nutrients furnished for 25 cents in food materials at prices in Eastern States.

Food materials as purchased.	Prices per pound.	25 cents will pay for—					Calories of poten- tial energy.
		Total food ma- terials.	Nutrients.				
			Total.	Protein.	Fats.	Carbo- hydrates.	
MEATS, ETC.	Cents.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Calories.
Beef, neck.....	8	3.13	0.95	0.49	0.44		2,765
	6	4.17	1.27	.65	.58		3,655
Chuck ribs.....	16	1.56	.56	.23	.31		1,735
	12	2.08	.75	.31	.42		2,355
Ribs	22	1.14	.47	.14	.32		1,615
	18	1.39	.57	.17	.39		1,960
Shoulder.....	14	1.79	.57	.30	.25		1,615
	10	2.50	.79	.43	.34		2,235
Sirloin	22	1.14	.37	.17	.19		1,120
	18	1.39	.45	.21	.23		1,360
Rump.....	18	1.39	.63	.19	.43		2,170
	15	1.67	.76	.23	.52		2,620
Round:							
First cut.....	18	1.39	.44	.25	.17		1,180
	15	1.67	.52	.30	.21		1,445
Second cut.....	10	2.50	.52	.35	.15		1,285
	8	3.13	.65	.44	.18		1,580
Flank, corned.....	15	1.67	.74	.21	.49		2,460
	10	2.50	1.11	.31	.73		3,655
Corned and canned	18	1.39	.66	.37	.24		1,700
	14	1.79	.85	.48	.31		2,200
Liver	8	3.13	.96	.63	.17	.11	2,095
Mutton:							
Shoulder.....	20	1.25	.44	.19	.24		1,365
	15	1.67	.58	.25	.31		1,775
Leg	25	1.00	.31	.15	.16		955
	20	1.25	.39	.19	.20		1,195
Loin.....	25	1	.43	.13	.29		1,465
	20	1.25	.53	.16	.37		1,860
Pork, rib roast.....	12	2.08	.88	.28	.58		2,970
	10	2.50	1.06	.34	.70		3,585
Smoked ham, whole	16	1.56	.81	.23	.54		2,705
	12	2.08	1.08	.31	.72		3,615
Salt fat pork	15	1.67	1.46	.02	1.38		5,860
	12	2.08	1.83	.02	1.72		7,295
Pork, sausage	15	1.67	.98	.23	.72		3,465
	12	2.08	1.22	.29	.89		4,295
Poultry, etc., chicken.....	22	1.14	.20	.17	.02		400
	16	1.56	.27	.24	.02		530
Turkey.....	23	1.09	.25	.18	.06		590
	18	1.39	.31	.22	.08		745
Fish, shad, whole.....	15	1.67	.25	.15	.09		660
	10	2.50	.37	.23	.12		935
	18	1.39	.22	.14	.06		515
Mackerel, whole.....	15	1.67	.25	.17	.07		610
	10	2.50	.37	.25	.11		930
Bluefish, dressed	15	1.67	.19	.16	.01		340
	10	2.50	.28	.25	.02		550
Striped bass, whole	18	1.39	.14	.12	.01		265
	12	2.08	.21	.17	.02		400
Haddock, dressed	8	3.13	.28	.26	.01		525
	5	5	.45	.41	.01		805
	10	2.50	.29	.27	.01		545
Cod, dressed	8	3.13	.36	.33	.01		655
	6	4.17	.48	.44	.01		860
Halibut, steaks,.....	20	1.25	.26	.19	.06		605
	16	1.56	.32	.24	.07		740
Salt cod	8	3.13	.55	.50	.01		970
	5	5	.88	.80	.02		1,570
Salt mackerel.....	16	1.56	.49	.23	.24		1,440
	12	2.08	.66	.31	.32		1,925
Canned salmon.....	20	1.25	.46	.25	.20		1,310
Oysters:							
50 cents per quart.....	25	1	.13	.06	.01	.04	230
35 cents per quart.....	17.5	1.43	.18	.09	.02	.05	345
Lobsters:							
Whole	12	2.08	.14	.11	.01		245
Canned.....	10	2.50	.17	.14	.02		345
	20	1.25	.28	.23	.01		470
EGGS AND DAIRY PRODUCTS.							
Eggs:							
35 cents per dozen.....	25	1	.23	.12	.10		645
25 cents per dozen.....	18.2	1.37	.32	.17	.14		910
15 cents per dozen.....	11	2.27	.53	.28	.23		1,490

CHEMISTRY AND ECONOMY OF FOOD.

TABLE 16.—Amounts of nutrients furnished for 25 cents in food materials at prices in Eastern States—Continued.

Nutrients furnished for 25 cents in food materials at prices in Eastern States—Continued.								
Food materials as purchased.	Prices per pound.	Total food materials.	25 cents will pay for—				Calories of potential energy.	
			Nutrients.					
			Total.	Protein.	Fats.	Carbo-hydrates.		
MISCELLANEOUS.								
Milk:								
8 cents per quart.....	4	6.25	.81	.23	.25	.29		2,020
6 cents per quart.....	3	8.33	1.08	.30	.33	.39		2,675
4 cents per quart.....	2	12.50	1.63	.45	.50	.59		4,045
Butter.....	35	.71	.64	.01	.60			2,550
	30	.83	.74	.01	.71			3,015
Cheese, whole milk.....	25	1	.90	.01	.85	.01		3,625
	18	1.39	.96	.40	.49	.02		2,850
Potatoes:	15	1.67	1.17	.47	.59	.03		3,420
\$1 per bushel.....	12	2.08	1.45	.59	.72	.04		4,210
80 cents per bushel.....	1.67	15	2.69	.27	.01	2.28		4,785
50 cents per bushel.....	1.33	19	3.41	.34	.02	2.09		6,090
Sweet potatoes.....	.83	30	5.38	.54	.02	4.56		9,570
Beets.....	5	5	1.27	.07	.02	1.14		2,335
	3	8.33	2.11	.10	.03	1.89		3,830
Turnips.....	2	12.50	1.23	.16	.01	.94		2,090
	1	25	2.45	.32	.02	1.87		4,180
Sugar.....	2	12.50	.93	.11	.02	.72		1,630
	1	25	1.86	.22	.04	1.44		3,260
Dried beans.....	5	5	4.90			4.89		9,095
	6	4.17	3.64	.96	.09	2.47		6,760
Maize, corn meal.....	5	5	4.37	1.15	.10	2.96		8,065
	4	6.25	5.46	1.44	.13	3.70		11,110
Oatmeal.....	3	8.33	7.08	.77	.32	5.88		13,720
	1	25	21.25	2.30	.95	17.65		41,160
Wheat flour.....	5	5	4.62	.76	.36	3.41		9,275
	4	6.25	5.47	.69	.07	4.68		10,285
Wheat bread.....	3.5	7.14	6.25	.79	.08	5.35		11,755
	3	8.33	7.29	.92	.09	6.24		13,695
Crackers, Boston.....	7	3.57	2.42	.31	.06	2.01		4,570
	5	5	3.38	.44	.09	2.82		6,445
	12	2.08	1.91	.22	.21	1.43		3,955
	8	3.13	2.87	.33	.31	2.15		5,920

CHAPTER IX.

FOOD CONSUMPTION.

A most important branch of the subject here considered is the actual food consumption of people of different countries and classes.

STUDIES OF DIETARIES—HISTORICAL SUMMARY.

A large number of observations have been made in Europe to learn the amounts of food and of actual nutrients consumed by people of different classes and occupations and under different circumstances. Within a very few years past like studies of dietaries have been undertaken in the United States and in Japan.

The method of making such observations consists in finding the amounts of food materials of different kinds consumed by one or more persons during a certain number of days and calculating the quantities of nutrients in each material from its amount and composition.

During some time past I have, with the aid of Drs. H. B. Gibson and C. F. Langworthy, endeavored to collate the results of the studies made in this direction up to the present time. We have found records of the examination of 491 separate dietaries, exclusive of army rations. The earliest were made in 1851 in England by Beneke, a German physician, afterwards professor in the University of Marburg. The majority have been made during the past 15, and by far the larger number of the most reliable ones during the past 10, years. The people whose dietaries have been studied have been of various classes, ages, and occupations. A few were in professional life and were decidedly well to do. The most were wage workers. Some of these were very poor, but the larger number were in reasonably comfortable circumstances as compared with the majority of people of like occupation in the countries where they lived.

Some of the studies were made with the greatest care and thoroughness, the food was accurately weighed and analyzed, and strict account was kept of the number, sex, and occupation of the persons who were nourished by it. In a few instances pains were taken to determine the proportions actually digested. But in a majority of the dietaries reported upon the amounts and composition of the food instead of being determined exactly by weighings and analyses were more or less roughly estimated, so that the results lack scientific accuracy.

From the 491 dietaries we have selected 338 as accurate enough to warrant their use in drawing inferences. The number of persons whose food consumption was observed in each dietary of this selected list

varied from a single individual to several hundred, and the time of observation in each case from 1 to 30 or more days. In addition to these the studies of some 41 Japanese and other Asiatic dietaries have been lately reported by Mori, Taniguti, and Eijkman, but we have not access to the details, a circumstance which is the more to be regretted because of the high value of the work.

In the selected list of 338 (columns A and B of table herewith) are included 101 studies of dietaries in the United States and Canada, of which 38 were in New England, 25 in Philadelphia, and 26 in Chicago. This list of 338 we have divided in two classes. The first including all the studies that seem to us reasonably accurate and complete; the second including those which are less accurate but sufficiently so to allow their results to be included in the general averages. The classification of all these dietaries by countries and by completeness of detail is summarized in the following tabular statement:

Number of dietaries collated, classified by countries and by completeness of detail.

[A. Reasonably accurate and complete. B. Less accurate, but included in averages. C. Not included in averages.]

	A	B	C	A+B	A+B+C
Europe:					
England.....		7	49	7	56
Scotland.....			6		6
Wales.....			1		1
Ireland.....			2		2
Total Great Britain.....		7	58	7	65
France.....		1	5	1	6
Belgium.....			15		15
Denmark.....	2			2	2
Sweden.....	13			13	13
Russia.....	4	25		29	29
Bavaria.....	21	34	7	55	62
Saxony.....		40	3	40	43
Prussia.....	3	13	15	16	31
Other German States.....	30	10	10	40	50
Total Germany.....	54	97	35	151	186
Austria.....		3		3	3
Switzerland.....	2		10	2	12
Italy.....	15		15	15	30
Spain.....			5		5
Portugal.....			1		1
Total Europe.....	90	133	144	223	367
Asia:					
India.....			7		7
Java ¹	1			1	1
Japan.....	8	5	1	13	14
Total Asia.....	9	5	8	14	22
Canada.....		13		13	13
United States:					
Massachusetts.....		19		19	19
Connecticut.....	13	5	1	18	19
Pennsylvania, Philadelphia.....		25		25	25
Illinois, Chicago.....		26		26	26
Total United States.....	13	75	1	88	89
Total North American.....	13	88	1	101	102
Grand total.....	112	226	153	338	491

¹Java Village, World's Fair, Chicago.

All of these studies in the United States were observed during the past 8 years. Those in Philadelphia and Chicago were observed by Miss Amelia B. Shapleigh in the use of the Dutton Fellowship of the College Settlements Association, 1892-93. The rest were studied by the writer and his associates at Wesleyan University, in cooperation with the Massachusetts Bureau of Labor and the United States Department of Labor, and as part of the work of the Storrs (Conn.) Experiment Station.

Of the European dietaries in the list only 7 are from England; these were estimated by Playfair some 30 years ago. Only 1 comes from France. Fifteen are from Sweden and Denmark and 29 from Russia. From Germany there are 151, of which the earliest were by Liebig and the larger number are by Voit and his followers. From Italy are 15, including 8 by Manfredi and 6 by Albertoni and Mori, which are among the latest and most thoroughly studied of all. From Japan are 13, all of which have been made lately by Germans connected with the University of Tokyo and by Japanese working with them. One was the dietary of Javanese in the Java Village at the World's Fair. This was studied in connection with the examinations of foods at the fair, under the direction of the writer, which were referred to in the statements regarding analyses of foods above.¹

The data thus collected are far from sufficient for satisfactory conclusions. Indeed, perhaps the most important lesson they teach is the need of more such studies. Their general character may be inferred from the selections in Table 37.

The only European country from which the studies are numerous and accurate enough to be taken as in any way representative of the national food consumption is Germany, although those from Denmark, Russia, and Italy are most interesting and instructive. The American data are confined to Massachusetts, Connecticut, Philadelphia, Chicago, and a few places in Canada. The right of those from the Eastern States to be taken as representative is confirmed, in a general way, by the figures for food consumption in the family budgets published by the Massachusetts bureau and the United States Department of Labor, especially in late reports of the latter on the cost of production.

SPECIAL INVESTIGATIONS OF DIETARIES.

It will be to the purpose here to cite some of the special studies of dietaries that have been made up to the present time as illustrative of the character of the work done, the methods followed, and the excellencies which may be imitated and the defects which should be abolished in future inquiry in this most important direction. To this end I select:

- (1) Several studies of dietaries in the United States, including some

¹Page 20.

of the earliest and the latest. The former are the least accurate; the latter are more thorough, though they are very far from being all that could be desired.

(2) A series made in Germany, which show how great care may be used in such inquiry and at the same time serve to illustrate the possibility of further improvement of method.

(3) A series of studies lately made in Italy, in which a decided advance in method is made in certain directions.

These illustrations will be followed by a résumé of the work in this direction up to the present time.

DIETARY STUDIES IN THE UNITED STATES.

In connection with the Massachusetts Bureau of Statistics of Labor, a series of studies of dietaries of factory operatives, mechanics, and other people with moderate incomes, in private families and boarding houses, were made by the writer in 1886. At the same time, and later, several dietaries of students and laborers and one of a well-to-do private family in Middletown, were examined. These were the first at all extended inquiries in this direction with which I am familiar in the United States. Although the work thus done represented only the beginning of an investigation of an important subject, the result seemed to warrant, or at least to suggest, generalizations of no little interest, and at the same time served to indicate directions in which further inquiry is needed. The following account of the Massachusetts and Canadian studies is taken from a report by myself and Mr. C. D. Woods in the report of the Storrs (Conn.) Experiment Station for 1891.

INVESTIGATION OF DIETARIES IN CONNECTION WITH THE MASSACHUSETTS BUREAU OF STATISTICS OF LABOR.

In order to obtain some definite information in regard to the ways of living and especially the food of factory operatives, mechanics, and other working people of native and foreign birth in Massachusetts, the statistics of the amounts and costs of food consumed, and age, sex, and occupation of the consumers, were collected by the bureau under the direction of its chief, Hon. Carroll D. Wright, in several manufacturing cities in the State; and as many of the people, whose conditions of life and labor were thus studied, were French Canadians, who come in large numbers to Massachusetts, as to other States bordering upon Canada, and form a not unimportant factor of the population, an agent of the bureau visited Canada and collated similar statistics regarding the people in the places from which they come. The data thus collated were placed in my hands, and with the assistance of Mr. E. W. Rockwood, then assistant in the chemical laboratory of Wesleyan University, the quantities of nutritive ingredients were estimated, the results of analyses of food materials to those of the dietaries being used as the basis of the calculations.

THE DIETARIES AND THE PEOPLE NOURISHED BY THEM.

From a larger number collated by the bureau, 30, which were regarded as representative, were selected for chemical examinations and the making up of average results. The 30 dietaries summarized in the tables of recapitulations are divided in three series, as follows:

Classification.	Series A, miscellaneous, Massachusetts.	Series B, French Canadian, Massachusetts.	Series C, French Canadian, Canada.
Data given in tables of recapitulation	5	5	5
Data not given, but results included in averages in tables of recapitulation	15	12	8
	10	7	13

¹Series A included 3 French Canadian dietaries which are averaged with those of series B, making 10 of the latter, all told, in the averages of series B, and only 7 in the averages for series A in the tables of recapitulations, beyond.

A. Miscellaneous, Massachusetts.—These include 10 dietaries of families and boarding houses. The families are nearly all laboring people, while the boarders in the boarding houses are mostly operatives in mills and factories, though some are clerks, dressmakers, etc. A few are French Canadians.

The 5 dietaries of this series, of which the data are given in the tables just referred to, include 3 of boarding houses and 2 of families in Lowell, Lynn, East Cambridge, and Boston. Two more of boarding houses, 1 in Lowell and 1 in Lawrence, are included only in the averages, for this series, in the tables. The results for 3 dietaries of French Canadian families in North Cambridge, of this series, are included in the averages for series B in the tables of recapitulations. The persons are factory and mill operatives, mechanics, etc., with a few clerks and dressmakers.

B. French Canadians, Massachusetts.—These include 7 dietaries of families and boarding houses, all of French Canadians. The 5 dietaries of this series which are used in the tables include those of 3 families and 2 boarding houses in Holyoke, Lawrence, and Lowell. Of those included only in the averages, 2 were of families in Worcester, of this series, and 3 of families in East Cambridge, of series A. With the exception of women, children, and others engaged in household duties, or in no actual labor, the people are mostly mill and factory operatives; a few are brickmakers.

C. French Canadians, Canada.—These include dietaries of 13 families and boarding houses in Montreal, Quebec, and other places in Canada. The people are represented as all belonging to the laboring classes. The 5 dietaries of this series which are used in the tables include 1 of a boarding house and 4 of families in Quebec, St. John, Sherbrooke, Richmond, and Rivière du Loup. The averages include, with these, 8 others of families and boarding houses.

Data.—In the descriptions given in the report of the kinds of data

employed and the ways in which they were attained, they were classified as follows:

Class A. Those contained in statistics as collected by the agents of the bureau. They have to do with:

I. Statistics of food materials, including: *a*, kind; *b*, quantity; *c*, costs.

II. Statistics of consumption of food materials, including: *a*, number; *b*, sex; *c*, age; *d*, occupation of persons nourished, and *e*, time.

Class B. Data obtained from other sources and used in the computations. They have to do with:

I. Chemical composition of the food materials. Proportions of nutrients (nutritive ingredients) in each. These figures were employed in computing the quantities of actual nutrients in the dietaries.

II. The proportions of nutrients required by persons differing in age, sex, etc. These proportions were used in estimating the numbers of men at moderate work who would be equivalent in demand for food to the men, women, and children nourished by the food for each dietary, the object being to place all the dietaries on a uniform basis for comparison.

In collecting the statistics of Class A, the agents of the bureau visited the houses where the people lived, and the cotton mills, shoe factories, glass factories, machine shops, blacksmith shops, brickyards, and other establishments where they worked, examined the bills of dealers for food furnished, the family and boarding house accounts, and by these and other appropriate means secured as accurate figures as practicable.

The chief source of error is undoubtedly to be found in the fact that the statistics give the amount of food purchased, not that actually eaten. How much was thrown away as refuse or otherwise wasted can not be ascertained.

Of the data of Class B, those regarding the composition of the food materials used were estimates rather than the record of actual analysis of the materials which would be required for entire accuracy. For the estimates the results of analyses made in this laboratory, and included with those reported in the chapter on "Composition of food materials," were employed. The other American analyses then available, mostly of dairy and cereal products, were also used. For the few materials of which no American analyses had been made, recourse was had to European figures. The data and methods used in estimating the composition of the food materials are given in detail in the report. The following quotations will give an idea of what they were. The tables referred to are too extensive to be inserted here. The analyses of beef were those described in the chapter on "Composition of food materials" above, as made for the United States National Museum.

The method of estimating the composition of beef was as follows:

A large amount, the larger part, we are informed, of the beef consumed in many of our Eastern cities is so-called "Chicago" or "Western" beef, which is slaughtered

in Chicago or elsewhere and brought East. From a car load of Chicago beef a side was selected by an experienced dealer as of average quality, especial pains being taken to secure one of average fatness. This side of beef was divided into 25 pieces, or "cuts," in the manner common in New York markets, and portions of each piece, sufficient to represent the whole, were analyzed, the proportions of refuse (bone, gristle, etc.), water, and nutrients being determined.

A diagram representing these divisions of the beef was placed in the hands of the collectors of the dietaries here examined, who, so far as practicable, indicated in their statements the parts of the animal from which the beef of the several dietaries was taken. The manner of cutting up the beef differs in different places, but not sufficiently to very materially affect the estimates. A more serious matter is the variation of different specimens of beef, and it is, of course, a question how close the side selected for analysis, as above stated, comes to representing the average of the kinds in the dietaries. We are informed that in all the Massachusetts cities, where the dietaries were collected, nearly all the beef used is so-called Chicago beef, and it is probable that the analyses fairly indicate the quality of the beef sold.

As the best way for utilizing these data, an assistant has gone over the dietaries, noted the cuts of beef where stated, and ascribed to each the percentages of nutrients found in the analyses of corresponding cuts. The results are shown in the following table. Where the original includes two or more cuts in one entry, the average is taken. The several computations for roast beef are averaged together. The same is done for beef stew, beefsteak, etc., and some of these latter averages are incorporated in the table beyond, giving the percentages of nutrients in food materials assumed in analyses of dietaries.

The figures used in calculating the amounts of nutrients in the dietaries are generally given in the table showing the percentages of nutrients in food materials assumed in analyses of dietaries. In some special cases, however, they are not given in this table, but are stated with explanations in the explanatory notes appended to the details of the dietaries in which they are used.

To insure perfect accuracy it would, of course, be necessary to analyze the materials actually used in each case. It is probable that while divergences, in some cases very wide, might occur, the figures for the composition of each dietary, as a whole, would be substantially accurate.

The item about which there seems to be the most question is the quantity of fat in the meats, especially the beef. The analyses here used accord very closely with European figures for very fat beef.¹ Numerous observations, however, which can not be detailed here, but which seem to be but little short of decisive, imply that the beef commonly used on the Continent of Europe is, on the average, less fat than the average beef in our markets. It is certain that much of that commonly used in our Eastern cities is very much fatter than that here analyzed and taken as the basis of these computations.

Attention has been called elsewhere to the fact that the figures for weights of food materials in the dietaries represent the quantities purchased and do not indicate how much was eaten. The rejection of a considerable part of the fat of meats by many persons is one of the most common of dietary facts, at least in the Northern and Eastern States. Some of the fat of beef is left with the butcher, much goes to the soap maker, and much more into the garbage. But a surprisingly large part of the fat of our beef is so diffused through the lean, much of it in invisible particles, that when we have cut out the larger pieces of fat from our roast beef or our steak and left them on our plates, we, nevertheless, eat the bulk of the actual fat of the meat with the lean and the small portions of visible fat which adhere to it.

Especial stress is laid on this point, because the dietaries here studied indicate a remarkably large consumption of fat in this country. The possible bearing of this fact upon our national dietetics may be extremely important.

¹ See analyses quoted by König, *Nahrungsmittel*, Bd. I.

In the statistics of some of the Massachusetts dietaries, and most of those collected in Canada, the quantities of certain food materials, especially vegetables, were not stated, and had to be estimated from the costs. The uncertainty as to the accuracy of the total estimates was thus increased, though, as was believed, not enough to seriously affect the value of the results for the purpose for which they were intended, namely, an exhibit of the general character of the food consumption and a means toward learning how such an inquiry may be best conducted.

The method for estimating the number of men, at moderate work, who would be equivalent in demands for nutriment to the persons partaking of the food of each dietary, is thus explained in the report:

Since the people nourished by the dietaries here examined differ in age, sex, and occupation, and hence differ likewise in their demands for nutriment, and since a chief object of the examination is to compare the dietaries with one another in respect to the quantities of actual nutrients supplied, it is clear that to attain our object we need some standard for estimating the relative demands of people of different classes. If, for instance, we could take a particular class, as laboring men at moderate work, and find to how many average men of this class the people nourished by each dietary would be equivalent in their demands for nutrients, we should simply have to divide the total quantity of nutrients supplied per day by this equivalent number of men to get the quantities per man per day. The results thus obtained for the several dietaries would, when compared with each other and with accepted standards, give us what we seek.

We are of the opinion that the experimental data on record in European work, if rightly collated and worked up, would give a basis for at least an approximate estimate of the comparative requirements of the several classes of persons into which those nourished by the food of these dietaries would most properly be divided. Indeed, the current standards for daily dietaries will help in arriving at such a basis. Thus, the standards of Voit and the Munich school of physiologists call for proportions of nutrients, with estimated potential energy, as follows:

Persons.	Protein.	Fats.	Carbo- hydrates.	Potential energy.
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
Children to 1½ years old.....	28	37	75	767
Children, 6 to 15 years old.....	75	43	325	2,041
Woman at ordinary work.....	92	44	400	2,426
Laboring man at moderate work.....	118	56	500	3,055

We may take the relative quantities of potential energy as the basis of our calculations. The figures are in about the following relative proportions. We interpolate an assumed value for children from 6 to 2 years of age.

Estimated relative quantities of potential energy in nutrients required by persons of different classes.

Laboring man at moderate work	10
Woman at ordinary work	8
Child, 15 to 6 years old.....	7
Child, 6 to 2 years old.....	5
Child, under 2 years old.....	2½

The application of these figures is simple. The food of dietary A, 1, for instance, suffices for 77 persons (factory operatives), 66 males and 11 females. The figures

allot to 1 working woman 0.8 as much nutritive material as to 1 laboring man at moderate work. This would make the 11 women equivalent to (8.8) 9 men, which added to 66 would make the whole 77 persons equal to 75 men. The 77 persons during 30 days, the time covered by the dietary, would be equal in requirements to 1 man for 2,250 days. The estimates in the dietaries hereinafter presented are made in this way.

The details of one of the dietaries are quoted to show the nature of the statistics collated by the bureau, and the way in which the quantities of nutrients were estimated. For statements of the ways in which the quantities were estimated from the costs in the cases in which they were not given, and for other details, the reader is referred to the original report, where the details of each of the 30 dietaries are given in full.

TABLE 17.—*Dietary. Series A, No. 1.*

[*Description.*—Boarding-house in Lowell, Mass., of 77 persons, 66 males and 11 females. Boarders, mill operatives. Time, 1 month. Estimated as equivalent in demands for nutrients to 75 laboring men at moderate work for 30 days, or 1 man for 2,250 days.]

FOOD MATERIALS AND NUTRIENTS.

Food materials.				Nutrients.		
Kinds.	Prices per pound.	Quantities.	Costs.	Protein.	Fats.	Carbo- hydrates.
	<i>Cents.</i>	<i>Pounds.</i>		<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Beef:						
Roast	10	400	\$40.00	60.4	79.9	.....
Steak	14	272	38.08	39.4	42.4	.....
Corned	7	350	24.50	40.3	99.8	.....
Tongue	10	62	6.20	9.2	9.5	.....
Stew	5	167	8.35	23.4	52.3	.....
Tripe	6	20	1.20	4.2	.2	.....
Pork, roast	10	150	15.00	17.1	54.3	.....
Ham	11	160	17.60	23.4	54.9	.....
Salt pork	10	70	7.00	2	53.6	.....
Lard	8	260	20.80	.....	257.4	.....
Haddock	7	168	11.76	13.9	.2	.....
Halibut	12	50	6.00	7.6	2.1	.....
Mackerel	3	40	1.20	4	1.6	.....
Salt fish (cod)	4½	50	2.25	8	.2	.....
Total meats, fish, etc		2,219	199.94	252.9	708.4	.....
Milk	2	3,024	60.48	102.8	111.9	145.2
Cheese	11	63.5	6.98	17.2	22.5	1.5
Butter	22 and 10	291	54.54	2.9	254.6	1.5
Eggs	14	107	14.82	12.4	10.9	.6
Total dairy products and eggs		3,485.5	136.82	135.3	399.9	148.8
Flour	3	1,568	47.04	174	17.2	1,182.3
Sugar	7½	600	45.00	.....	.....	580.2
Molasses	4½	99	4.50	.....	.....	70.3
Beans	3	124	3.74	28.8	2.6	66.6
Rice	8	25	2.00	1.9	.1	19.9
Oatmeal	4	25	1.00	3.8	1.8	16.8
Potatoes	1	2,520	25.20	47.9	5.0	463.7
Squash	1½	250	3.75	1.3	.3	13.3
Onions	2	26	.50	0.3	.....	2
Beets	5.9	90	.50	1.6	.1	9
Turnips	5.6	120	1.00	1.1	.2	6.1
Tomatoes	5.6	120	1.00	1.6	.4	5.4
Apples	1½	300	5.00	.9	.....	32.7
Raisins	12½	24	3.00	.6	.1	15.1
Currants	10	15	1.50	.3	.....	9.5
Corn starch	9	12	1.08	.....	.....	11
Crackers	5	48	2.40	5.1	4.8	34
Total vegetable food		5,966	148.21	269.2	32.6	2,537.9
Total animal food		5,704.5	336.76	388.2	1,108.3	148.8
Total food		11,670.5	484.97	657.4	1,140.9	2,686.7

TABLE 17.—*Dietary. Series A, No. 1*—Continued.

FOOD MATERIALS AND NUTRIENTS—Continued.

Food materials.				Nutrients.		
Kinds.	Prices per pound.	Quantities.	Costs.	Protein.	Fats.	Carbo- hydrates.
	<i>Cents.</i>	<i>Pounds.</i>		<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Meats, fish, etc., per man per day		.09	\$0.09	.11	.31	.....
Dairy products and eggs, per man per day		1.55	.06	.06	.18	.07
Animal food, per man per day		2.54	.15	.17	.49	.07
Vegetable food, per man per day		2.65	.07	.12	.01	1.13
Total food, per man per day		5.19	.22	.29	.50	1.20

Results.—The three tables which follow recapitulate the details of fifteen of the dietaries.

Tables 18 and 19 recapitulate the statistics of the dietaries, as explained by their titles.

Table 20 summarizes in shorter form the principal results set forth in the two preceding.

TABLE 18.—Recapitulation of statistics of dietaries.
PERSONS, EMPLOYMENTS, WAGES, ETC., AND QUANTITIES AND COSTS OF FOOD.

Food materials per man per day.											
Series and No. of dietary.	Persons, employments, wages, etc.	Quantities.				Costs.					
		Animal food.				Vegetable food.					
		Meats, fish, etc.		Dairy prod. and eggs.		Meats, fish, etc.		Dairy prod. and eggs.			
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.		
Wages per day.		Occupation.		Total food.		Total food.		Total food.		Number of dietary.	
Males.	Females.	Males.	Females.	Lbs.	Lbs.	Cts.	Cts.	Cts.	Cts.		
PERSONS, EMPLOYMENTS, WAGES, ETC.											
MISCELLANEOUS, MASSACHUSETTS.											
A 11	Family, East Cambridge	1 \$4.00		Father, glass blower	Lbs. 0.66	Lbs. 1.48	Lbs. 2.97	Lbs. 4.45	Cts. 9	Cts. 25	A 11
A 1	Boarding house:										
A 7	Lowell			Mill operatives	.99	1.55	2.65	5.19	6	15	A 1
A 7	Lynn			Operatives, etc ²	.71	.91	3.48	5.10	5	15	A 7
A 2	Lowell			Mill operatives	.98	1.29	2.66	4.93	10	15	A 2
A 9	Family, Boston	33.52		Husband, machinist	1.36	1.64	4.17	7.17	24	36	A 9
	Average of 7 dietaries				.88	1.29	3.02	5.19	11	17	
FRENCH CANADIAN, MASSACHUSETTS.											
B 6	Family, Holyoke	1.35	\$0.90		.46	.21	2.35	3.02	7	10	B 6
B 4	Boarding house, Holyoke ⁴	1.25	90		.95	.80	2.76	4.51	12	18	B 4
B 1	Family, Lawrence	(— ⁵)	90	Mill operatives	.92	.66	3.01	4.59	14	18	B 1
B 5	Boarding house, Holyoke	(— ⁶)	(⁷)		1.05	.39	4.25	5.69	14	19	B 5
B 10	Family, Lowell	2.00 ⁹	1.00	Men, blacksmiths ⁸	1.28	1.51	4.40	7.19	18	29	B 10
	Average of 10 dietaries				.81	.70	3.44	4.95	11	16	
FRENCH CANADIAN, CANADA.											
C 18	Boarding house, Rivière du Loup				.36	.19	1.65	2.20	4	6	C 18
C 12	Family:										
C 12	St. John				.35	.44	2.02	2.81	3	6	C 12
C 26	Richmond				.63	.45	2.82	3.90	5	8	C 26
C 24	Sherbrooke				1.13	.55	2.43	4.11	9	13	C 24
C 6	Quebec				.57	.98	2.25	3.80	5	10	C 6
	Average of 13 dietaries				.52	.45	2.49	3.46	5	8	
PERSONS, EMPLOYMENTS, WAGES, ETC.											
1 Wages \$24 per week, work exhausting. 2 Operatives in shoe factory, dressmakers, clerks.											
5 \$1.25 to \$1.75 per day. 6 \$1.25 to \$1.50 per day. 7 90 cents to \$1 per day.											
8 Woman mill operative. 9 \$600 per year.											
4 Board per week, \$2.75 for men, \$2 for women.											

TABLE 18.—*Recapitulation of statistics of dietaries—Continued.*
 QUANTITIES OF NUTRIENTS ESTIMATED PER MAN PER DAY.

Series and No. of dietary.	Dietaries.	Nutrients supplied by different classes of food materials.										Total nutrients supplied.			Of every 100 parts of protein the different food materials furnish parts as below.			
		Protein.			Fats.			Carbohydrates.				Hundredths of a pound.	Grams.	Meats, fish, etc.	Dairy products and eggs.	Total.	Vegetable food.	
		Animal food.			Vegetable food.			Meats, fish, etc.	Dairy products and eggs.	Total.	Vegetable food.							Protein.	Fats.	Carbohydrates.
		Meats, fish, etc.	Dairy products and eggs.	Total.	Meats, fish, etc.	Dairy products and eggs.	Total.					Meats, fish, etc.	Dairy products and eggs.	Total.	Protein.	Fats.	Carbohydrates.	
A 11	MISCELLANEOUS, MASSACHUSETTS.	.07	0.03	0.10	.11	.02	0.02	0.03	1.03	0.21	0.29	1.06	95	481	33	14	47	53
A 1		.11	.06	.17	.12	.01	.01	.07	1.13	.29	.50	1.20	132	545	38	21	59	41
A 7		.09	.04	.13	.12	.02	.02	.04	1.11	.25	.33	1.15	114	522	36	16	52	48
A 2		.11	.05	.16	.13	.01	.01	.06	1.15	.29	.44	1.21	132	549	38	17	55	45
A 9		.17	.08	.25	.15	.04	.04	.07	1.29	.40	.56	1.36	182	617	42	20	62	38
	Average of 7	.11	.05	.16	.12	.02	.02	.06	1.11	.28	.41	1.17	127	531	39	18	57	43
B 6	FRENCH CANADIANS, MASSACHUSETTS.	.04	.02	.06	.12	.02	.02	.....	1.09	.18	.29	1.09	82	495	22	11	33	67
B 4		.09	.04	.13	.08	.01	.01	.03	.69	.21	.59	.72	95	327	43	19	62	38
B 1		.10	.03	.13	.12	.01	.01	.03	1.12	.25	.41	1.15	114	522	40	12	52	48
B 5		.10	.02	.12	.19	.02	.02	.01	1.21	.31	.59	1.22	141	554	32	7	39	61
B 10		.15	.08	.23	.21	.04	.04	.05	1.70	.44	.67	1.75	200	795	34	18	52	48
	Average of 10	.08	.04	.12	.14	.02	.02	.02	1.19	.26	.45	1.21	118	549	31	15	46	54
C 18	FRENCH CANADIANS, CANADA.	.04	.01	.05	.11	.02	.02	.....	.85	.16	.19	.85	73	386	25	6	31	69
C 12		.05	.01	.06	.12	.02	.02	.02	.93	.18	.20	.95	82	431	28	5	33	67
C 26		.09	.02	.11	.12	.02	.02	.02	1.13	.23	.22	1.15	104	522	39	9	48	52
C 24		.14	.02	.16	.17	.03	.03	.02	1.16	.33	.37	1.18	150	536	42	6	48	52
C 6		.08	.04	.12	.17	.02	.02	.04	1.09	.29	.22	1.13	132	513	27	14	41	59
	Average of 13	.07	.02	.09	.15	.03	.03	.02	1.14	.24	.24	1.16	109	527	29	8	37	63

TABLE 19.—Persons stated to be nourished by food of dietaries, and estimated numbers of laboring men at moderate work who would require the same quantities of nutrients.

Series and No. of dietary.	Persons reported.	Classification.					Total number of persons.	Estimated equiv- alent to labor- ing men.
		Adults.		Children.				
		Males.	Fe- males.	15 to 6 years.	6 to 2 years.	Under 2 years.		
	MISCELLANEOUS, MASSACHUSETTS.							
A 11	Father, mother, 1 other adult female, and 3 children of 5, 11, and 12 years..	1	2	2	1	.....	6	4½
	Boarding house:							
A 1	66 males and 11 females.....	66	11	.....	.....	.....	77	75
A 7	20 males and 16 females.....	20	16	.....	.....	.....	36	33
A 2	10 males and 60 females.....	10	60	.....	.....	.....	70	58
A 9	Husband and wife.....	1	1	.....	.....	.....	2	1½
	FRENCH CANADIAN, MASSACHUSETTS.							
B 0	Father, mother, 2 adult children, ¹ and 2 children of 9 and 12½ years.....	2	2	2	.....	.....	6	5
B 4	Boarding house, 8 men, 7 women, and 3 children	8	7	3	.....	.....	18	15½
B 1	Father, mother, and 4 adult children, 1 female	4	2	.....	.....	.....	6	5½
B 5	Boarding house, 6 males and 4 females, ages 16 to 40 years	6	4	.....	.....	.....	10	9½
B 10	Two brothers ² and a sister, adults.....	2	1	.....	.....	.....	3	3
	FRENCH CANADIAN, CANADA.							
C 18	Boarding house, 15 adults	8	7	.....	.....	.....	15	13½
C 12	Father, mother, and 8 children, 2 to 13 years old	1	1	5	3	.....	10	6¾
C 26	Father, mother, and 3 children of 9, 12, and 14 years.....	1	1	3	.....	.....	5	4
C 24	Father, mother, and 2 children, 6 months and 5 years old	1	1	.....	1	1	4	2½
C 6	Father, mother, and 6 children, 1 to 12 years old	1	1	3	2	1	8	5

¹ One male and one female.² The men, blacksmiths, were at rather severe work, hence the 2 with 1 woman are estimated as equivalent to 3 men at moderate manual labor.TABLE 20.—Summary of statistics of dietaries.¹

QUANTITIES OF FOOD MATERIALS.

Food materials.	Series A, miscellaneous, Massachusetts.			Series B, French Canadian, Massachusetts.			Series B, French Canadian, Canada.		
	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Meats, fish, etc.....	1.36	0.63	0.88	1.28	0.46	0.81	1.13	0.35	0.52
Milk, butter, cheese, and eggs.....	1.70	.82	1.29	1.51	.21	.70	.98	.14	.45
Total animal food.....	3.00	1.48	2.17	2.79	.67	1.51	1.68	.54	.97
Vegetable food.....	4.17	2.38	3.02	5.65	2.35	3.44	3.65	1.65	2.49
Total food.....	7.17	4.12	5.19	7.26	3.02	4.95	4.89	2.20	3.46

¹ The figures for maximum and minimum indicate the largest and smallest quantities in any single dietary, and those for average, the averages of all the dietaries of each series. Thus, the largest quantities of meat, etc., per man per day in any of the dietaries of Series A was 1.36 pounds, the smallest 0.63 pounds, and the average of the 7 dietaries of this series examined was 0.88 pound. The largest amount of total food in any single dietary of this series was 7.17 pounds, the smallest 4.12 pounds, and the average 5.19 pounds. That the figures for total do not always equal the corresponding sum (for instance, the total animal food, maximum, Series A, is less than the sum of the figures for meats, fish, etc., and for milk, butter, cheese, and eggs) is due to the fact that the factors which would make up the sum are from different dietaries, while the figures for total are the maximum, minimum, etc., for individual dietaries.

TABLE 20.—*Summary of statistics of dietaries*¹—Continued.

COSTS OF FOOD MATERIALS.

Food materials.	Series A, miscellaneous, Massachusetts.			Series B, French Canadian, Massachusetts.			Series B, French Canadian, Canada.		
	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.
	<i>Cts.</i>	<i>Cts.</i>	<i>Cts.</i>	<i>Cts.</i>	<i>Cts.</i>	<i>Cts.</i>	<i>Cts.</i>	<i>Cts.</i>	<i>Cts.</i>
Meats, fish, etc.....	24	6	11	18	6	11	9	3	5
Milk, butter, cheese, and eggs.....	12	4	6	11	3	5	7	1	3
Total animal food	36	10	17	29	10	16	13	5	8
Vegetable food.....	11	6	8	13	6	8	8	5	6
Total cost.....	47	16	25	39	17	24	19	11	14

NUTRIENTS IN FOOD MATERIALS.

	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>
Protein	0.40	0.21	0.28	0.44	0.18	0.26	0.33	0.16	0.24
Fats	.56	.29	.41	.67	.28	.45	.39	.16	.24
Carbohydrates	1.36	1.65	1.17	1.75	.72	1.21	1.59	.85	1.16
Total nutrients.....	2.32	1.56	1.86	2.86	1.52	1.92	2.29	1.20	1.64
Percentages of animal protein in total protein food.....	64	47	57	62	33	46	48	29	37

¹ The figures for maximum and minimum indicate the largest and smallest quantities in any single dietary, and those for average, the averages of all the dietaries of each series. Thus, the largest quantities of meats, etc., per man per day in any of the dietaries of Series A was 1.36 pounds, the smallest 0.63 pound, and the average of the 7 dietaries of this series examined was 0.88 pound. The largest amount of total food in any single dietary of this series was 7.17 pounds, the smallest 4.12 pounds, and the average 5.19 pounds. That the figures for total do not always equal the corresponding sum (for instance, the total animal food, maximum, Series A, is less than the sum of the figures for meats, fish, etc., and for milk, butter, cheese, and eggs) is due to the fact that the factors which would make up the sum are from different dietaries, while the figures for total are the maximum, minimum, etc., for individual dietaries.

Discussion of results.—The discussion of the dietary statistics involves details of local interest, but the following quotations from the report will serve to show some of the ways in which such information can be made useful. It will be remembered that Series A, miscellaneous, Massachusetts, includes dietaries of factory and mill operatives, mechanics, and a few clerks, dressmakers, etc., of various nationalities, in Lowell, Lawrence, Lynn, East Cambridge, and Boston. Series B, French Canadians, Massachusetts, includes factory operatives and a few mechanics of Canadian origin, working in Massachusetts. Series C, French Canadians, Canada, includes similar people, mainly or entirely laboring classes in Canada. In other words, the people had only very moderate incomes, and the majority were factory operatives, a class of whom we ordinarily think as living on rather a low plane of material comfort. The following statements are from the report referred to:

In the following table (21) the averages of the analyses of dietaries are succinctly set forth:

TABLE 21.—*Averages of statistics of dietaries.*

QUANTITIES OF FOOD MATERIALS.

Food materials.	Series A, miscellaneous, Massachusetts.	French Canadian.	
		Series B, Massachusetts.	Series C, Canada.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Animal.....	2.17	1.51	0.97
Vegetable.....	3.02	3.44	2.49
Total.....	5.19	4.95	346

COSTS OF FOOD MATERIALS.

	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>
Animal.....	17	16	8
Vegetable.....	8	8	6
Total.....	25	24	14

NUTRIENTS IN FOOD MATERIALS.

	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Protein.....	127	118	109
Fats.....	186	204	109
Carbohydrates.....	531	549	527
Total.....	844	871	745
Animal protein in 100 of total protein.....	57	46	37

DIETARY OF A BOARDING HOUSE IN CONNECTICUT.

The Storrs (Conn.) Experiment Station has lately cooperated with the United States Department of Labor in the study of a number of dietaries. Some of the results of the studies have been published by the station in its reports for 1891-1893. The work has been done under the writer's direction in the chemical laboratory of Wesleyan University. The following account of the study of the dietary of a boarding house was published in the report of the station for 1891.

The details of the investigation were carefully carried out by Mr. H. B. Gibson, at that time assistant chemist to the station. During the whole period of the investigation Mr. Gibson boarded at the house and kept account of everything purchased and of kitchen and table wastes.

The general plan of the investigation included account of all food materials of nutritive value in the house at the beginning, that purchased during and that which remained at the end of the experiment. In addition to this all the kitchen and table wastes of the food were collected, taken to the laboratory, and there weighed and analyzed. The amount of different food materials on hand at the beginning and received during the experiment were added; from this sum the amounts remaining at the end were subtracted. This gave the amount of each material actually used. From the amounts thus obtained and the

composition of each material as shown by analysis, the amounts of the nutritive ingredients were estimated. From this were subtracted the amounts of nutrients in the waste, and thus the amounts of nutrients in the food actually eaten were learned.

Duration of the experiment.—The dietary commenced with supper, October 20, 1890, and continued until after dinner of November 19, a period of 30 days.

Members of the family and meals eaten.—During most of the time the family consisted of 13 men and 7 women. It very rarely happened that all of the family took all three meals at the house any given day. There were occasional visitors, and in this way once or twice the total number of meals taken per day was larger than the family alone would have required. The sex, approximate age, and occupation of each member of the family, as it was constituted most of the time, were as follows:

Men:		
Machinists, 30 to 40 years of age	4	
Machinist, about 35, after October 25.....	1	
Harness maker, about 70.....	1	
Hired men, one old, the other middle aged.....	2	
Proprietor of the house, about 70.....	1	
Manufacturers, one about 60, the other about 30.....	2	
Chemist, about 27.....	1	
Reporter for newspaper, about 20, after October 27.....	1	
	—	
Total	13	
Women:		
Housekeeper, about 30.....	1	
Cook, about 45.....	1	
Table girl, about 20.....	1	
Doing no manual labor, about 30, 55, 55, and 70.....	4	
Young lady at house 4 days, doing no labor.....	1	
	—	
Total	8	

Of the 13 men, 3 were counted as “hearty eaters,” and 6 more as having decidedly good appetites.

An account of the number of meals taken each day was kept, and is given in the following table:

Number of meals taken at the house each day.

Date.	Men.	Wo-men.	Date.	Men.	Wo-men.	Date.	Men.	Wo-men.
Oct. 20.....	10	7	Oct. 31.....	37	20	Nov. 11.....	38	13
21.....	32	21	Nov. 1.....	42	18	12.....	38	16
22.....	29	23	2.....	40	16	13.....	38	14
23.....	32	25	3.....	40	16	14.....	37	16
24.....	32	23	4.....	36	16	15.....	38	16
25.....	30	17	5.....	39	18	16.....	37	18
26.....	25	21	6.....	38	19	17.....	37	18
27.....	34	19	7.....	36	18	18.....	37	19
28.....	35	19	8.....	37	16	19.....	21	11
29.....	35	18	9.....	33	14			
30.....	34	18	10.....	33	13	Total.....	1,060	536

The actual number of meals taken at the house during the 30 days of the experiment was 1,596, of which 1,060 were eaten by men and 536 by women. Assuming, in accordance with the dietary standards given in the succeeding chapter, that on the average one woman ate eight-tenths as much as one man, this would reduce the whole number of meals to an equivalent of 1,489 for the 30 days, or 3 meals per day for 496 days for 1 man.

Food used during the experiment.—The actual amount of food and of nutrients in the food used during the dietary is shown in Table 22, which follows. The weights of the food materials are as they were purchased and used; that is, they include bone and other refuse except where specified.

The first three columns in the table contain the percentages of protein, fat, and carbohydrates used in computing the amounts of these nutrients in the different food materials.

In nearly all cases analyses were made of specimens of the food materials actually used in the dietary, or of specimens so nearly identical with those used that they might properly serve for the analysis. The analysis was omitted in a few cases, but only where previous analyses were thought to furnish reasonably accurate data for estimates of the composition.

TABLE 22.—*Food materials used in dietary of boarding house for 13 men and 8 women during 30 days.*

Food materials.	Percentage composition.			Weights used.			
	Protein.	Fat.	Carbo- hydrates.	Total food ma- terials.	Nutrients.		
					Protein.	Fat.	Carbo- hydrates.
ANIMAL FOODS.							
Beef:	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Short steak.....	18.6	19.2	.....	5,780	1,075	1,109	.....
From soup bones.....	16.8	30.3	.....	1,100	185	333	.....
Chuck ribs.....	13.2	19.7	.....	18,270	2,412	3,599	.....
Do.....	15.2	28.7	.....	3,290	500	944	.....
Do.....	16.3	13.3	.....	2,720	443	362	.....
Do.....	15.6	17.8	.....	2,780	434	495	.....
Shoulder.....	17.3	8.8	.....	2,610	452	230	.....
Roast, free from bone.....	17.1	19.9	.....	2,780	475	552	.....
Do.....	16.1	32.9	.....	2,500	403	823	.....
Do.....	16	32	.....	2,160	346	691	.....
Do.....	16.8	30.3	.....	2,670	449	809	.....
Do.....	15.2	36.6	.....	2,720	413	996	.....
Suet.....	.9	94.6	.....	340	3	322	.....
Corned.....	13.2	21.3	.....	14,050	1,855	2,993	.....
Do.....	11.7	37.2	.....	9,370	1,096	3,485	.....
Corned, canned.....	24.5	20.2	.....	11,168	2,736	2,256	.....
Dried.....	29.9	4.5	.....	3,400	1,017	1,153	.....
Tripe.....	13.5	1.9	.....	2,950	398	56	.....
Bologna sausage.....	18.8	15.8	.....	3,970	746	627	.....
Total.....	.....	.....	.....	94,628	15,438	21,835	.....
Veal:							
Shoulder.....	18.3	5.5	.....	9,750	1,784	536	.....
Miscellaneous cuts.....	14.9	10.2	.....	3,400	507	347	.....
Total.....	.....	.....	.....	13,150	2,291	883	.....
Pork:							
Ribs.....	13.5	25.4	.....	3,400	459	864	.....
Ribs and shoulder.....	14.1	25.6	.....	6,410	904	1,641	.....
Shoulder.....	13.8	28.9	.....	1,470	203	425	.....

TABLE 22.—*Food materials used in dietary of boarding house for 13 men and 8 women during 30 days—Continued.*

Food materials.	Percentage composition.			Weights used.			
	Protein.	Fat.	Carbo- hydrates.	Total food ma- terials.	Nutrients.		
					Protein.	Fat.	Carbo- hydrates.
ANIMAL FOODS—continued.							
Pork—Continued.	<i>Per cent.</i>	<i>Per cent</i>	<i>Per cent.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Chops	13.2	31.9	.....	8,560	1,130	2,731	.....
Salt, fat.....	.9	82.8	.....	1,250	113	1,035	.....
Ham, smoked.....	14.8	34.6	.....	22,340	3,306	7,730	.....
Sausage	11.2	45.4	.....	8,280	928	3,759	.....
Lard .....	.....	90	.....	6,350	.....	5,715	.....
Total.....	.....	.....	.....	58,060	7,043	23,900	.....
Lamb:	.....	.....	.....	.....	.....	.....	.....
Ribs.....	16.7	22.1	.....	4,650	777	1,028	.....
Shoulder	13.5	22.8	.....	11,790	1,592	4,280	.....
Leg	15.6	12.6	.....	6,340	989	789	.....
Total.....	.....	.....	.....	22,780	3,358	6,097	.....
Fowl and chicken	15.1	1.2	.....	14,290	2,158	171	.....
Fish:	.....	.....	.....	.....	.....	.....	.....
Flounder, dressed	6.3	.3	.....	4,200	265	13	.....
Haddock, dressed	9.9	.2	.....	6,860	679	14	.....
Cod, salt.....	16	.4	.....	790	126	3	.....
Round clams, shell contents	6.5	.4	.....	3,910	254	16	.....
Total.....	.....	.....	.....	15,760	1,324	46	.....
Dairy products, etc.:	.....	.....	.....	.....	.....	.....	.....
Butter.....	.....	80	.....	34,190	.....	27,352	.....
Milk	3.5	4.5	4.9	191,400	6,699	8,613	9,379
Cheese	27.1	35.5	2.3	1,130	306	401	26
Total.....	.....	.....	.....	226,720	7,005	36,366	9,405
Eggs	12.2	10.2	.....	12,560	1,532	1,281	.....
Total animal foods .....	.....	.....	.....	457,948	40,149	90,579	9,405
VEGETABLE FOODS.							
Onions (10 per cent refuse)	1.4	.3	10.1	6,120	86	18	618
Sweet potatoes (12.5 per cent refuse)	1.5	.4	26	30,564	458	122	7,947
Potatoes (15 per cent refuse)	2.1	.1	17.9	98,175	2,062	98	17,573
Squash (50 per cent refuse).....	.9	.2	10.1	3,400	31	7	343
Cabbage (15.5 per cent refuse)	1.5	.2	5.7	14,895	223	30	849
Turnips (30 per cent refuse).....	1.2	.2	8.2	38,150	458	76	3,128
Canned corn.....	3	1.3	22.5	3,870	116	50	871
Canned peas.....	4.3	.3	11.4	3,945	170	12	449
Canned tomatoes	1	.2	3.7	5,190	52	10	192
Dried beans	22.2	1.4	60.3	4,080	906	57	2,460
Apples (25 per cent refuse).....	.3	.4	15.9	33,875	102	136	5,385
Cranberries	.4	.9	10.9	2,640	11	24	288
Grapes (25 per cent refuse)	1.7	1.7	21.3	10,120	172	172	2,156
Flour.....	13.5	1.3	74	124,500	16,908	1,619	92,130
Buckwheat flour.....	6.9	1.4	76.1	1,810	125	25	1,377
Corn starch, tapioca, and pearl barley .....	.....	.....	97.5	1,130	.....	.....	1,102
Hominy	8.2	.4	77.4	2,270	186	9	1,757
Oatmeal.....	15.1	7.1	68.2	1,470	222	104	1,002
Crackers	10.7	9.9	68.8	1,360	146	135	936
Sugar (water-free).....	.....	.....	100	60,780	.....	.....	60,780
Molasses and sirup (63 per cent sugar).....	.....	.....	63	6,630	.....	.....	418
Total.....	.....	.....	.....	454,974	22,434	2,704	201,761
Total animal and vegetable foods .....	.....	.....	.....	912,922	62,583	92,262	211,166

NOTE.—100 grams = 3.5 ounces, or 0.22 pounds. 1 ounce = 28.35 grams. 1 pound = 453.6 grams.

The data of Table 22 are summarized in Table 23, in which the weights are stated in pounds as well as in grams. As before explained, it was estimated that the food consumption was equivalent to that for one man for a period of 496 days. The table gives the quantities estimated per man per day on this basis. These figures apply to the food as purchased.

TABLE 23.—*Weights of food materials and of nutritive ingredients used.*

RECAPITULATION OF DIETARY OF BOARDING HOUSE.

Food materials.	Food materials.	Nutrients.			Food materials.	Nutrients.		
		Protein.	Fats.	Carbohy- drates.		Protein.	Fats.	Carbohy- drates.
FOR 21 PERSONS, 30 DAYS.								
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>
Meats, etc	202,908	30,288	52,886	.....	446	67	116	.....
Fish	15,760	1,324	46	.....	35	3	.....	.....
Dairy products:								
Butter	34,190	.....	27,352	.....	75	.....	60	.....
Cheese	1,130	306	401	26	3	1	1	.....
Milk	191,400	6,699	8,613	9,379	421	15	19	21
Total	226,720	7,005	36,366	9,405	499	16	80	21
Eggs	12,560	1,532	1,281	.....	28	3	3	.....
Total animal food	457,948	40,149	90,579	9,405	1,008	89	199	21
Vegetable food	454,974	22,434	2,704	201,761	1,001	49	6	444
Total food	912,922	62,583	93,283	211,166	2,009	138	205	465
PER MAN PER DAY.								
Meats, etc	409	61.1	106.6	.....	.9	.....	.....	.....
Fish	32	2.7	.1	.....	.1	.....	.....	.....
Dairy products:								
Butter	69	.....	55.2	.....	.2	.....	.....	.....
Cheese	2	.6	.8	.....	.....	.....	.....	.....
Milk	386	13.5	17.4	18.9	.8	.....	.....	.....
Total	457	14.1	73.4	18.9	.1	.....	.....	.....
Eggs	25	3.1	2.6	.....	.1	.....	.....	.....
Total animal food	923	81	182.7	18.9	2.1	.18	.40	.04
Vegetable food	917	45.2	5.5	406.9	2	.10	.01	.90
Total food	1,840	126.2	188.2	425.8	4.1	.28	.41	.94

Table 23 tells its story so plainly as to require little comment. It will, however, be interesting to note the proportion of the several kinds of food materials in the dietary and the relative proportions of the several nutrients furnished by each. These are expressed in percentages in Table 24. Thus in the column under "Total food materials," it will be observed that the meats make up 22.2 per cent, the milk 21 per cent, and the butter and cheese sufficient to make the total dairy products 24.8 per cent; the animal food altogether 50.1, and the vegetable food 49.9 per cent of the total food purchased. Of the whole protein 48.4 per cent was supplied in the meats, 2.2 per cent in the fish, and so on.

TABLE 24.—Percentages of food materials of different classes and of nutrients furnished by each class.

Food materials.	Total food ma- terials.	Nutrients.		
		Protein.	Fats.	Carbohy- drates.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Meats, etc	22.2	48.4	56.7	.....
Fish	1.7	2.2	.1	.....
Dairy products:				
Butter	3.7	.....	29.3	.....
Cheese	.1	.5	.4	.1
Milk	21	10.7	9.2	4.4
Total	24.8	11.2	38.9	4.5
Eggs	1.4	2.4	9.2	.....
Total animal food	50.1	64.2	97.1	4.5
Vegetable food	49.9	35.8	2.9	95.5
Total food	100	100	100	100

*Table and kitchen refuse and waste.*¹—These were made up of bones of meat, parings of potatoes, etc., left in preparing the food for the table, and the scraps of food left on the table uneaten. The percentages of refuse of vegetables and meats were obtained from experiment as described in the footnote. All of the table and kitchen refuse and waste, except parings of vegetables and bones of meat, were carefully collected after each meal and taken to the laboratory. It was there freed from bone and other inedible materials, and then dried for 24 hours or more in large evaporating dishes in a water oven at 98° C., as usual in preparing for analysis. While still hot, the fat was removed as far as possible, so as to leave the samples in better condition for

¹The terms “refuse” and “waste” and the ways of determining the amounts demand a word of explanation. The weights given for the food materials in Table 22 are those found by weighing them as received, and with few exceptions include both edible portion and refuse. The exceptions are stated in the table, e. g., “Beef, roast, free from bone.” The proportions of refuse in the meats were found by weighing the refuse and edible portion of the specimens analyzed. The percentages of refuse and edible portion thus found are given in the tables of composition of animal foods, in the chapter on “Composition of food materials” of the present report. Those figures for refuse accordingly represent actually inedible material and not waste in the proper sense, i. e., valuable material wasted, except in so far as the bone, etc., may be utilized for soup. The figures in Table 22 for refuse of the vegetable foods, e. g., parings of potatoes and turnips, stem and outside leaves of cabbage, rind and seeds, etc., of squash, were determined approximately by weighings at the house. They represent not only the actually inedible material, but also more or less of edible material removed with it. For instance, it was estimated from weighings of the parings of the potatoes that out of 100 pounds, 15 pounds were removed in the kitchen and only 85 pounds served on the table. These 15 pounds were made up in part of the skin and adhering earth, which might be properly called refuse. The rest was edible material, which, if it had been saved and served, would have been as wholesome as that which went on the table, and may be appropriately designated as waste. The terms refuse and waste are here used somewhat indiscriminately. Perhaps a correct terminology would make the refuse consist of the actually inedible material and waste, the latter term covering the edible material rejected with the refuse. While the use of terms is unimportant, the subject itself is an important one for American household economy.

grinding. The water-free fat thus removed amounted in all to 2,639 grams. It is accounted for in Table 25. The partly dried refuse was allowed to accumulate till 5 kilograms or more had accumulated, and was then sampled and prepared for analysis. Eight such lots of material were collected and analyzed. The weights of the water-free refuse and its constituents are given in Table 25 herewith.

TABLE 25.—Percentages and weights of nutrients in table and kitchen wastes.

Laboratory number.	Percentage composition.				Weight of ingredients.				
	Protein.	Fats.	Carbo-hydrates.	Ash.	Total water-free substance (nutritive materials).	Nutrients.			
						Protein.	Fats.	Carbo-hydrates.	Ash.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per ct.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
307	27.44	40.94	28.52	3.10	5,514	1,513	2,258	1,573	170
310	26.81	31.57	37.31	4.31	5,772	1,548	1,822	2,154	248
313	28.56	38.89	28.84	3.71	4,478	1,279	1,742	1,291	166
317	26.50	36.50	32.42	4.58	4,653	1,233	1,698	1,509	213
324	28.38	37.39	30.44	3.79	4,831	1,371	1,806	1,471	183
328	32.75	40.83	21.45	4.97	5,659	1,853	2,311	1,214	281
334	31.31	40.59	23.46	4.64	5,198	1,628	2,110	1,219	241
336	25.94	33.27	36.28	4.51	4,215	1,093	1,402	1,529	191
Fat removed as above explained					2,639		2,639		
Total grams.....					42,959	11,518	17,788	11,960	1,693
Equivalent to pounds					94.4	25.3	39.1	26.3	3.7

NOTE.—100 grams = 3.5 ounces, or 0.22 pounds. 1 ounce = 28.35 grams. 1 pound = 453.6 grams.

TABLE 26.—Nutrients and potential energy in food purchased, rejected, and eaten.

	Nutrients.			Potential energy.
	Protein.	Fats.	Carbo-hydrates.	
WHOLE EXPERIMENT, 21 PERSONS, 30 DAYS.				
Food purchased:	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
Animal	40,149	90,579	9,405	1,045,560
Vegetable	22,434	2,704	201,761	944,350
Total	62,583	93,283	211,166	1,989,910
Waste:				
Animal	10,190	17,621	-----	205,650
Vegetable	1,328	167	11,960	56,030
Total	11,518	17,788	11,960	261,680
Food actually eaten:				
Animal	29,959	72,958	9,405	839,900
Vegetable	21,106	2,537	189,801	888,310
Total	51,065	75,495	199,206	1,728,210
PER MAN PER DAY.				
Food purchased:				
Animal	81	182.7	18.9	2,110
Vegetable	45.2	5.5	406.9	1,900
Total	126.2	188.2	425.8	4,010
Waste:				
Animal	20.5	35.5	-----	410
Vegetable	2.7	.3	24.1	110
Total	23.2	35.8	24.1	520
Food actually eaten:				
Animal	60.4	147.1	18.9	1,690
Vegetable	42.6	5.1	382.8	1,790
Total	103	152.2	401.7	3,480

TABLE 26.—*Nutrients and potential energy in food purchased, etc.*—Continued.

TOTAL FOOD PURCHASED.

	Nutrients.			Potential energy.
	Protein.	Fats.	Carbo-hydrates.	
Food purchased:	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Animal	64.2	97.1	4.5	52.5
Vegetable.....	35.8	2.9	95.5	47.5
Total	100	100	100	100
Waste:				
Animal	16.3	18.9	.....	10
Vegetable.....	2.1	.2	5.6	2.7
Total	18.4	19.1	5.6	12.7
Food actually eaten:				
Animal	47.9	78.2	4.5	41.2
Vegetable.....	33.7	2.7	89.9	43.7
Total	81.6	80.9	94.4	84.9

NOTE.—100 grams = 3.5 ounces, or 0.22 pounds. 1 ounce = 28.35 grams. 1 pound = 453.6 grams.

It will be worth while to estimate, as well as may be, how much of the nutritive material wasted came from the animal and how much from the vegetable food. As there were practically no carbohydrates in any of the animal food materials except milk and cheese, and but little in these, we shall not greatly err in assuming that all the waste carbohydrates came from the vegetable foods. For a rough calculation, it will also be safe to assume that the proportions of protein and fat in the vegetable portion of the waste were the same as in the whole vegetable food. In the latter the weight of the protein is 11.1 per cent and that of fat 1.4 per cent of the weight of the carbohydrates. Taking the same percentages of the weight of the carbohydrates in the total waste as the measure of the protein and fats in the vegetable waste, we have the actual weights of protein and fats in the latter. Subtracting these weights of vegetable protein and fat from the total weights of these ingredients in the waste, we have as the remainder the amounts of animal protein and fat in the whole waste.

The proportions of nutritive ingredients in the food purchased, in the waste, and in the food actually consumed are given in Table 26, on the preceding page. The estimates of animal and vegetable nutrients in the waste are computed as above described, and those of potential energy as explained above.

About one-ninth of the total nutritive ingredients of the food was left in the kitchen and table wastes. The actual waste was worse than this proportion would imply, because it consisted mostly of the protein and fats which are more costly than the carbohydrates. The waste contained nearly one-fifth of the total protein and fat, and only one-twentieth of the total carbohydrates of the food. Or, to put it in another way, the food purchased contained about 23 per cent more protein,

24 per cent more fats, and 6 per cent more carbohydrates than were eaten. And, worst of all for the pecuniary economy or lack of economy, the wasted protein and fats were mostly from the meats which supply them in the costliest form. At the ratio in which the nutrients were actually eaten in this dietary, the protein in the waste would have sufficed 1 man for 112 days; the fats would have supplied him also for 112 days, and the carbohydrates for 30 days.

DIETARIES OF HAND WEAVERS IN ZITTAU, SAXONY.

An investigation of the conditions of living, with reference especially to income and expenditure of a class of poor people, weavers, in Zittau, a district in eastern Saxony, was made in 1885 by Von Schlieben, and reported in a publication¹ of the Saxon Bureau of Statistics. Later, Von Rechenberg, who had been connected for some time with the laboratory of the Agricultural Institute of the University of Leipsic, and had been engaged with Professor Stohmann in the combustion of food materials, became interested to study the food consumption of these people more fully, and has, with the aid of the Royal Saxon Society of Sciences, published the results of his inquiry in considerable detail.²

The following summary is taken in part from the report of Von Schlieben, but in the main from that of Von Rechenberg:

Zittau is one of the few localities in Germany where weaving on a large scale is still done by hand. The persons over 16 years of age engaged in this industry, in 1885, numbered 8,000 out of a population of somewhat over 73,000, distributed throughout 65 villages. The industry is an old one; so long ago as 1729 statistics concerning it were gathered by the Government.

The majority of the weavers in 1885 were over 30 years of age and more than half were over 40.

The stuffs woven are linen toweling, bed linen, damask, cotton and woolen cloth, and similar wares.

The hours of work are very protracted, ranging from 5 or 6 a. m. to 8 or 9 p. m. in summer and from 6 or 7 a. m. to 11 p. m. in winter; that is, 13 to 14 hours a day in summer and 14 to 16 hours in winter.

The old-fashioned wooden looms are used. In the weaving of cloth of ordinary width the muscular exertion is not severe, as the work is done while sitting; but some of the cloth is very wide, and in making this severe exertion is required. In fact, the long-continued practice of weaving extra wide cloth with the pressure of the body against the loom often produces serious internal disorders.

From 3 to 5 marks (1 mark equals about 24 cents) per week are earned for weaving the ordinary kinds of cloth, and from 5 to 10 marks for the extra wide and fine wares. The latter sums are, however, the exception.

¹Zeitschrift des k. sächsischen statischen Bureaus, 1885, Parts III and IV, pp. 156-190.

²Die Ernährung der Handweber in der Amtshauptmannschaft, Leipzig, 1890.

In several cases the reported earnings of a man and wife together aggregated only about 300 marks per year.

The habits and mode of life of these people are very simple. The house often consists of only 3 rooms. The largest is the general living room; in this the weaving is done. The two smaller are used as bedroom and kitchen.

The weaving is done by both the man and woman, in so far as the household duties of the latter permit. The children when not in school help in winding the thread and in other ways.

The extremely weak physical condition of these weavers incapacitates them, as a rule, for farm work; but occasionally the more robust ones work on the farms for a few weeks during harvest time.

The larger part of the earnings of these people is spent for food. In none of the families did the amount paid for food fall below one half of the total income, and in several cases it reached four-fifths. The average expenditure for food was found to be about two-thirds of the total income.

An idea of their condition may be gained from the fact that while the climate is about like that of southern New England, something like \$7.50 per year would be the average sum expended per family for fuel for heating, cooking, and other household purposes. Many gather part of the fuel they use in the public forests or on the large estates of families living in this region. Of course they are allowed to collect only such materials as small twigs and branches which have been blown from the trees. Others prepare fuel in summer by kneading together a mixture of cheap brown coal and peat, shaping it into cakes and drying it.

The food of these people is of the simplest kind. Variations from the regular diet are very exceptional. Meat is rarely eaten except on Sunday and then in small quantities, and even among the better class of weavers such luxuries as beer are indulged in only on great occasions.

The diet is not peculiar to this region, but is similar to the so-called "potato diet" so common among German peasants. The term "potato diet" is somewhat misleading. In reality rather more than half of the total food is bread, and only in exceptional cases would the quantity of potatoes be more than one-third of the whole.

The physical condition of these people is far from what might be desired. There is a notable lack of muscular energy. Still the weavers are by no means short lived. When the household duties of the woman are so great as to keep her from the loom, her physical condition is usually superior to that of the man. The young children are more healthy than the older ones.

Notwithstanding the unfavorable conditions of life, the people seem contented with their lot, and Dr. von Rechenberg regards them as much better off than many families of factory operatives in cities like

Leipsic who have much larger incomes, but whose occupations deprive them of home life.

After a general idea of the condition of life of the Zittau hand weavers had been gained by discussing the subject with the leading men, employers and employed, and by visiting many families in a number of villages, 52 families were selected as representative of the class which made the best use of the means at their disposal. To these were given blanks to fill out. The character of the questions and answers in these blanks may be inferred from the following translation of one of them. The answers to the questions are in italics:

QUESTION CARD TO AID IN DETERMINING THE CONDITIONS OF A WEAVER'S FAMILY
IN DITTELSDORF.

[Family No. 2.]

1. Age of husband, 56. Age of wife, 71. Number of children. Age of children (*Childless*).

2. Number and kind of rooms in house? *One living room, 1 bedroom, 1 attic, 1 small cellar.*

3. What are the chief articles of diet—bread or potatoes, or vegetables and flour? *Bread, flour, and potatoes.*

4. How often in the week is meat eaten, and is beef or pork preferred? *Once, pork preferred.*

5. Weekly expenditures for food, etc.?

Expenditures for food, etc., in one week.

Kinds of material purchased.	Quantity.		Cost.	
	<i>Liters.</i>	<i>Kilos.</i>	<i>Marks.</i>	<i>Pfennigs.</i>
Bread.....		7	1	35
Flour.....		$\frac{1}{2}$		18
Rye flour.....		1		28
Potatoes.....	8			35
Vegetables (peas, beans, rice, etc.).....		$\frac{1}{2}$		13
Chicory.....		$\frac{1}{8}$		5
Sugar.....				11
Rolls (bread).....				12
Milk.....	$\frac{1}{2}$			6
Butter.....		$\frac{1}{2}$	1	10
Sour-milk cheese.....		$\frac{1}{2}$		6
Meat.....		$\frac{1}{4}$		30
Fish (herring).....				8
Salt.....		$\frac{1}{4}$		5
Pepper and other spice.....				2
Soap.....				10
Starch.....				5
Soda (for washing).....				3
Petroleum.....	$\frac{1}{2}$			12
Candles.....				3
Total for 1 week.....			4	59
Total for 52 weeks.....			238	68

6. House rent per year? *House is owned.* Marks.¹

7. Clothing per year (shoemaker, tailor, linen, etc.)..... 10.00

8. Coal and wood per year..... 25.60

9. Dishes and cooking utensils per year..... .50

10. School tax per year.....

11. State tax per year..... 5.00

¹ The mark equals 24 cents, nearly.

	Marks.
12. Village tax per year	5.00
13. Insurance, life, accident, etc .....	.....
14. Expenditure for pleasure away from home, beer, tobacco, etc .....	.....
Total.....	46.10
Food, etc.....	238.68
Grand total.....	284.78

The topics of the remaining questions were the income derived from hand weaving and from other sources; whether any land was owned, if so, how it was worked; for whom weaving was done; what sort of cloth was made; the hours of work, and the expenditures necessary to carry on the weaving (weaver's paste, repairs of loom, etc.).

Among the further details reported are the following: The man and wife are spare and the man is often ill. The wife is healthy and in spite of her age can still weave. The man weighs 52 kilos (111.4 pounds), the woman 41 kilos (90 pounds), and neither is strong enough to work in the field. The wheat flour mentioned in the table was used to make weaver's paste. Vegetables mentioned are rice, millet, and grits. The milk used is skimmed milk or buttermilk.

The daily meals in this family are: Breakfast, flour soup (porridge), coffee, bread, butter; dinner, potatoes, salt, coffee, bread, butter; lunch (afternoon), bread, butter; supper, skimmed milk or buttermilk, bread, butter. This is the diet winter and summer, except that during the winter porridge is eaten for supper instead of milk.

In the opinion of the neighborhood this family lived very sparingly, yet it is the regular weaver's diet common to this region.

It will be seen that the greater part of this diet is bread, potatoes, flour, and coffee. The other food amounts to very little, in few cases exceeding 10 per cent of the total.

Green vegetables are too expensive to form any considerable factor in the diet except with families who own gardens.

The diet is such that it is impossible to improve it without material increase of cost. It is evidently shaped by long experience in the conditions in which the people are placed.

In these families no guests are entertained nor are any meals taken away from home except on an occasional feast day.

There is practically no food wasted. As one woman said in reply to a question concerning waste: "Everything is eaten up at our house. We are too poor to throw anything away."

These people say emphatically that they have enough to eat. They are completely satisfied after dinner and go to bed without hunger. Dr. von Rechenberg thinks this satiety is doubtless due in a great measure to the badly ventilated rooms in which they work and live, and to the monotony of their food.

The data collated in these dietary studies are concisely summarized in the following tables:

TABLE 27.—*Statistics of 28 families of hand weavers, numbers of persons, and annual income and expenditure of each family.*

Reference No. of family.	Family consists of ¹ —						Total annual income.	Annual expendi- tures.		Ratio of expendi- ture for food to total ex- penditure.
	Father.		Mother.		Children.			Total.	For food.	
	Age.	Weight.	Age.	Weight.	Num- ber.	Ages.				
	<i>Years.</i>	<i>Kilos.</i>	<i>Years.</i>	<i>Kilos.</i>		<i>Years.</i>	<i>Marks.</i>	<i>Marks.</i>	<i>Marks.</i>	<i>Per cent.</i>
2	56	52	71	41	0	.....	286	286.28	212.16	74.1
3	55	72	53	38	0	.....	445	473.88	366.60	77.4
9	34	59	32	54	0	.....	478.64	457.34	299	65.4
24	53	.....	51	.....	0	.....	321	308.66	231.92	75.1
37	57	55	56	50	0	.....	344.1	386.1	234	63.6
38	57	75	56	67	0	.....	319	319.46	219.96	68.9
45	59	60	53	53	0	.....	405.6	385.80	314.08	81.5
1	29	50	24	55	4	1, 3, 9, 10	546	590.19	433.68	73.5
24	43	61	40	57	2	12, 18	1307	1141.8	752.44	65.9
8	53	47	53	44	1	12	477.8	465.82	284.44	61.1
11	44	62	42	.....	2	5, 6	435	439.36	317.72	72.3
12	44	56	40	52	4	3, 8, 11, 14	633	632.17	449.28	71.1
16	58	65	54	58	2	25, 3	469	484.53	366.08	75.5
17	58	61	47	.....	1	6	465	468.17	340.08	72.6
21	57	62	38	50	4	3, 11, 13, 14	648	671	520	77.5
31	41	70	35	70	8	1, 3, 5, 7, 9, 11, 13, 15	676	707.6	589.16	83.3
32	48	50	48	53	3	10, 12, 14	603	618.	342.16	58.6
233	50	44	49	59	2	8, 11	1115	1088.32	569.92	52.4
35	47	59	43	55	3	2, 4, 9	465	470	326.08	69.4
36	37	65	32	57	4	1, 3, 5, 6	465	464.14	342.16	73.7
40	31	57	28	49	2	3, 8	542	551	363.48	66
41	31	55	31	50	2	4, 8	298	297	195	65.7
43	36	50	34	41	2	3, 8	435	427.26	267.28	62.5
44	47	56	38	50	4	1, 5, 10, 13	470	462.42	268.84	58.1
46	28	52	23	.....	2	2, 5	482	479.82	383.76	80
47	35	60	40	50	3	9, 10, 12	413.5	436.40	264.16	60.5
49	36	75	35	62	3	4, 7, 14	533.6	531.99	334.88	62.9
52	32	56	28	61	2	4, 6	320	338.32	248.04	73.3
Average	.....	59		54	.....	.....	524	523	351	67
Average of childless families							395	397	268	68
Average of families with children							568	566	379	67

¹ Average weight of men and women, 57 kilos.

² Husband (in No. 4, the father and 18-year-old son) wove especially wide cloth.

TABLE 28.—*Weekly food consumption of families of weavers.*

Reference No. of family.	Rye bread.	Rye flour.	Pota- toes.	Butter.	Lard, etc.	Bacon, smoked.	Vege- tables (dry). ¹	Rice.	Milk.	Skim- med milk.	Butter- milk.
	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Liters.</i>	<i>Liters.</i>	<i>Liters.</i>
Without chil- dren.	2	7	1	6	0.5			² 0.5			0.5
	3	9	1	7.5	.75	0.25	0.25	1.5			
	9	9	.5	7.5	.75	.15		.25	1		
	24	7	1	5.25	.5			.25	.5	1.5	
	37	6.0	1	7.5	.5	.25		.25	1.5		
	38	7.5	.75	7.5	.5	.20		.25	1		1
	45	8.5	1.5	6	.5		.33	5			4
	1	15	3	12	1				.3		
With children.	4	18	.75	20	1.5	.5		.5	.5		
	8	12	1.5	7.5	.5				.1		
	11	12	1	2.4	.75				.8		
	12	18	2	22.5	1	.25		1	1.5		
	16	12	1	9	.75	.25		.375		12.5	
	17	9		9	.75		.125			8	
	21	18	2	37.5	1.5				1		
	31	28	3	22.5	1	.5			.5		
	32	15	1.5	14.4	1	.15		.25	2		
	33	9	.5	22.5	1	.065	.375	.25	3.5		
	35	12	2	15	.75	.15		.25		1	
	36	10.5	1.25	18.75	.5	.375	1		2.5		
	40	13.25	1	25	.75				2		
	41	6	1.5	12	.35	.075		.25	.5		.7
	43	7	1	12	.5			.45			7
	44	9	1.5	10	.5			.58			7
	46	12	2	26.25	1				3		
	47	12.5	1	15	.5		.125	.25		1.5	
	49	12.5	1	10.6	1	.25		³ .5	2		
	52	12	2	11.25	.5				.5		

Reference No. of family.	Goat's milk.	Curd.	Eggs.	Her- ring.	Beef.	Pork.	Sugar.	Coffee.	Coffee substi- tutes, chicory, etc.	Rolls.	Sirup.	Fruit.
	<i>Liters.</i>	<i>Kilos.</i>	<i>No.</i>	<i>No.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>
Without chil- dren.	2		0.5		1		0.25	0.15		0.125	0.3	
	3	1			1		.5	.125		.25	.9	
	9			1.5		0.55		.06	0.075	.15	.4	
	24		.25		1	.5		.125		.2		
	37					.25		.15	.10	.125		
	38		.375		1	.125		.03	.04	.075	.33	
	45					.5		.10	.10	.25	.66	0.5
	1		.3		2		.25	.07		.375	.9	
With children.	4			6	6	1		.25	.5	.25	1.5	
	8		.5		1	.25		.125	.125	.25		
	11		.75		2					.25		
	12				2							
	16		.5		1	.125	.125	.125	.125	.125	.3	1
	17				.5	.5		.125	.125	.125	.5	.5
	21		.25					.04	.25			
	31		.47		1		.175	.25		.125	.83	
	32			.5		.25		.125		.375	.3	
	33		.235	2	2	1		.25	.25	.125	1.33	
	35		.55		2		.5	.05		.2	.67	
	36		.47		6	.325		.08	.06	.375	.9	
	40							.125	.125	.25		
	41		.47		2	.125	.125			.2		
	43		.25		1	.5		.15	.15	.15	1.4	
	44	1			1	.125		.05	.1	.125	.4	
	46		.47						.125	.25		
	47				.5	.09			.04	.125	.06	
	49				1	.5				.125	.83	
	52						.05			.075		

¹ I. e., as distinct from green vegetables.² Rice, barley grits, and millet.³ Millet.

TABLE 29.—*Rates of potential energy of each food material to that of total food used by weavers.*

Kind of food.	Energy ratio to total energy.	Kind of food.	Energy ratio to total energy.
	<i>Per cent.</i>		<i>Per cent.</i>
Rye bread	54.8	Herring	.4
Rye flour	6.9	Beef and pork	.7
Potatoes	18.4	Sugar	.6
Butter	9.1	Coffee and coffee substitutes	.8
Fat and bacon	2.1	Rolls	1.6
Vegetables, rice, barley, grits, and millet	1.6	Sirup	.1
Milk, skimmed milk, buttermilk, and goat's milk	2.3	Fruit	.04
Curd	.6	Total	100
Eggs	.04		

TABLE 30.—*Estimated composition, digestibility, and potential energy of the food materials of weavers.*

[The figures are for estimated weights of nutrients in 100 grams of each kind of solid material, and for 100 cubic centimeters each of milk and beer. For eggs and herrings, however, the weights are for the number stated in each case.]

Food materials.	Nutrients.						Potential energy in nutrients.	
	Protein.		Fats.		Carbohydrates.		Total.	Digestible.
	Total.	Digestible.	Total.	Digestible.	Total.	Digestible.		
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>	<i>Calories.</i>
Beef:								
Medium fat, without bones	20.91	20.39	5.19	4.31	.....	.....	132	122
Medium fat, with 15 per cent bones	17.78	17.33	4.41	3.66	.....	.....	112	104
Pork:								
Fat, without bones	14.54	14.18	37.34	30.99	.....	.....	409	348
Fat, with 10 per cent bones	13.09	12.76	33.61	27.89	.....	.....	368	313
One herring, weight 135 grams, with 37 per cent refuse	16.07	15.67	14.36	11.92	.....	.....	199	174
Bacon, smoked	2.60	2.54	77.80	64.57	.....	.....	742	617
Lard	.26	.25	99.04	94.09	.....	.....	934	887
Cow's milk	3.51	3.35	3.77	3.66	4.96	4.96	69	67
Cow's milk, skimmed	3.22	3.04	.77	.74	4.91	4.91	40	39
Buttermilk	4.20	4.20	.96	.96	3.86	3.86	44	44
Curd	18.61	17.77	4.23	4.10	3.94	3.94	136	131
Butter	.71	.71	83.27	81.60	.58	.58	771	771
Goat's milk	3.62	3.46	4.05	3.93	4.52	4.52	70	68
One hen's egg, contents 47 grams	5.90	5.73	5.69	5.41	.....	.....	77	73
Rye bread	6.11	4.28	.43	.22	49.25	49.79	231	203
Rye flour	11.52	8.64	2.08	1.14	69.66	68.35	351	326
Wheat flour	11.82	9.46	1.36	.75	72.23	71.17	357	337
Wheat rolls	6.15	4.92	.44	.24	51.12	50.38	239	229
Potatoes, with 9 per cent refuse (skins, etc.)	1.80	2.70	.14	.10	19.51	17.92	86	80
Rice	7.85	6.25	.88	.48	76.75	76.06	356	342
Millet	10.82	8.61	5.46	3	67.75	67.15	372	338
Barley grits	7.25	5.77	1.15	.63	76.19	75.50	353	340
Peas	22.85	18.85	1.79	.65	54.90	52.90	329	295
Beans	23.21	19.15	2.14	.77	56.20	54.20	340	303
Vegetables, dry, average	12.20	9.90	2.40	1.20	68.40	67.50	354	330
Fruit, fresh, average	.54	.54	.....	.....	³ 17	14.71	68	58
Sugar .....	.....	.....	.....	.....	99	99	⁴ 383	⁴ 383
Beer:								
Ordinary .....	.....	.....	5.80	.80	1.63	1.63	412	412
Lager, light .....	.....	.....	⁵ 3.46	3.46	5.49	5.49	445	445
Bavarian export beer .....	.....	.....	⁵ 4.31	4.31	6.48	6.48	55	55
Coffee, infusion from 100 grams roasted coffee .....	.....	.....	5	5	13	13	95	95
Chicory and other coffee substitutes, infusion from 100 grams .....	.....	.....	1	1	55	55	221	221

¹Omitting crude fiber except in potatoes and fruits. ²The nonalbuminoid nitrogen is deducted.

³Free acid, 0.71; sugar, 7.97; cellulose, 4.32; nitrogen-free extract, 4.01; total, 17 per cent. ⁴The energy of sugar is taken at 3,866 calories per gram. ⁵Alcohol (instead of fats) in 100 cubic centimeters.

TABLE 31.—*Estimated nutrients and energy in daily food of each family of weavers.*

Reference No. of family.	Nutrients.						Potential energy in nutrients.		
	Protein.		Fats.		Carbohydrates		Total.	Digest- ible.	
	Total.	Digest- ible.	Total.	Digest- ible.	Total.	Digest- ible.			
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>	<i>Calories.</i>	
Without chil- dren.	2	125	91	88	80	873	810	4,868	4,444
	3	170	124	203	183	1,200	1,119	7,462	6,810
	9	135	97	131	119	975	907	5,725	5,210
	24	127	91	78	71	813	756	4,534	4,129
	37	107	77	114	104	799	743	4,737	4,311
	38	117	84	109	99	1,029	957	5,158	4,694
	45	160	115	118	107	933	868	6,115	5,565
	1	252	179	175	159	1,817	1,688	10,036	9,155
	4	311	223	322	303	2,164	2,000	13,032	11,966
	8	176	126	86	78	1,253	1,155	6,613	5,991
With children.	11	212	153	118	107	1,643	1,528	8,597	7,823
	12	261	188	188	171	2,105	1,958	11,347	10,326
	16	229	165	164	149	1,372	1,276	8,028	7,305
	17	168	121	126	115	1,056	982	6,120	5,569
	21	300	216	210	191	2,541	2,363	13,345	12,144
	31	381	274	237	216	2,980	2,771	15,998	14,558
	32	217	156	171	156	1,717	1,597	9,441	8,591
	33 ¹	219	158	217	197	1,508	1,402	8,991	8,182
	35	192	138	161	147	1,568	1,458	8,733	7,947
	36	216	156	170	155	1,516	1,410	8,590	7,817
	40	207	149	117	106	1,783	1,658	9,133	8,311
	41	142	102	81	74	956	889	5,217	4,747
	43	188	135	88	80	1,151	1,070	6,269	5,705
	44	212	153	92	84	1,216	1,131	6,675	6,074
	46	219	158	158	144	1,822	1,694	9,772	8,893
	47	179	129	91	83	1,450	1,349	7,460	6,789
	49	194	140	188	171	1,408	1,309	8,258	7,515
	52	170	122	78	71	1,374	1,278	6,996	6,366

¹ Husband (in No. 4, father and 18-year-old son) wove extra wide cloth.TABLE 32.—*Estimated amounts of protein fats and carbohydrates and potential energy of the digestible food of the men and the women of the weavers' families, per day.*

Ref- erence No. of family.	Men.				Women.				Poten- tial energy for adults.
	Pro- tein.	Fats.	Carbo- hy- drates.	Poten- tial energy.	Pro- tein.	Fats.	Carbo- hy- drates.	Poten- tial energy.	
	Grams.	Grams.	Grams.	Cals.	Grams.	Grams.	Grams.	Calories.	
Without chil- dren.	2	49	43	437	3,297	42	37	373	2,047
	3	81	114	698	4,250	43	69	421	2,560
	9	50	61	467	2,682	47	58	440	2,528
	24	47	37	419	2,125	44	34	394	2,004
	37	37	51	361	2,093	40	53	382	2,218
	38	44	51	496	2,435	40	48	461	2,259
	45	63	59	477	3,057	52	48	391	2,508
	1	43	43	461	2,503	52	46	492	2,668
	4	69	95	622	3,719	60	82	540	3,240
	8	49	30	455	2,359	47	29	435	2,257
With children.	11	56	39	558	2,862	51	36	509	2,609
	12	47	43	496	2,611	45	41	470	2,475
	16	53	47	404	2,317	49	44	375	2,149
	17	52	49	419	2,378	48	45	386	2,192
	21	57	50	616	3,162	49	43	533	2,738
	31	47	37	474	2,489	47	37	474	2,489
	32	40	40	413	2,267	42	42	429	2,308
	33	51	66	466	2,686	55	69	487	2,866
	35	45	47	471	2,568	43	45	449	2,450
	36	47	47	434	2,369	53	53	470	2,692
	40	55	40	618	3,098	50	36	559	2,801
	41	37	27	322	1,717	35	25	302	1,611
	43	51	30	405	2,160	45	26	354	1,891
	44	42	23	311	1,666	39	21	288	1,544
	46	57	53	615	3,300	59	54	631	3,385
	47	38	25	401	2,019	34	22	355	1,787
	49	42	51	393	2,256	37	45	346	1,986
	52	42	25	439	2,180	44	26	465	2,317

Estimated average daily metabolism of material and energy per average person.

	Protein.	Fats.	Carbo- hydrates.	Potential energy.
	Grams.	Grams.	Grams.	Calories.
Total food consumed.....	65	49	485	2,703
Digestible portion of food consumed.....	47	45	451	2,461

TABLE 33.—*Estimated potential energy per day in the food (digestible portion) of the children of weavers' families.*

[Ages of children.]

Reference No. of family.	Months.		Years.							
	Four.	Nine.	One.	Two.	Three.	Four.	Five.	Six.	Seven.	Eight.
	Cals.	Cals.	Cals.	Cals.	Cals.	Cals.	Cals.	Cals.	Cals.	Cals.
1.....			564		915					
4.....										
8.....										
11.....							1,157	1,196		1,176
12.....					896					
16.....					790					
17.....								999		
21.....		643								
31.....			543		881		1,053		1,120	
32.....										
33.....										
35.....				755		973				1,212
36.....	521				804		961	992		
40.....					1,044					1,369
41.....						646				772
43.....					717					940
44.....			350				679			
46.....				993			1,414			
47.....										
49.....						823			954	
52.....						873		983	983	
Average..	521	643	486	874	864	829	1,053	1,043	1,037	1,094

Reference No. of family.	Years.								
	Nine.	Ten.	Eleven.	Twelve.	Thirteen.	Fourteen.	Fifteen.	Eighteen.	Twenty-five.
	Cals.	Cals.	Cals.	Cals.	Cals.	Cals.	Cals.	Cals.	Cals.
1.....	1,236	1,272							
4.....				1,975				3,035	
8.....				1,376					
11.....									
12.....			1,378			1,789			
16.....									2,048
17.....									
21.....			1,605		1,918	2,083			
31.....	1,190		1,354	1,364	1,618		1,819		
32.....		1,126				1,615			
33.....			1,420						
35.....	1,199								
36.....									
40.....									
41.....									
43.....									
44.....		790			1,043				
46.....									
47.....	910	936		1,134					
49.....									
52.....						1,497			
Average..	1,134	1,031	1,439	1,462	1,526	1,746	1,819	3,035	2,048

TABLE 34.—*Estimated money and fuel values of food materials in diet of weavers.*

Food materials.	Market price.	Fuel value of digest- ible por- tion. ^a	Calories (net values) obtained for one mark.	1,000 calo- ries (net values) cost.
		<i>Calories.</i>	<i>Calories.</i>	<i>Marks.</i>
Potatoes, 9 per cent refuse	0.056 mark per kilo	800	14,288	0.070
Rye flour	.2467 mark per kilo	3,260	13,213	.076
Rye bread	.1867 mark per kilo	2,030	10,873	.092
Wheat flour	.3256 mark per kilo	3,370	10,346	.097
Vegetables, "dry" ^b	.346 mark per kilo	3,300	9,538	.105
Fruit, fresh	.08 mark per kilo	580	7,250	.138
Skimmed and buttermilk	.06 mark per liter	420	7,014	.143
Roll	.333 mark per kilo	2,290	6,877	.145
Lard, rendered	1.35 mark per kilo	8,870	6,473	.152
Curd	.213 mark per kilo	1,310	6,157	.163
Cow's milk	.123 mark per liter	670	5,447	.184
Bacon, smoked	1.49 mark per kilo	6,170	4,140	.241
Sugar	.95 mark per kilo	3,830	4,043	.248
Butter	2.06 mark per kilo	7,560	3,667	.272
Pork, with 10 per cent bones	1.146 mark per kilo	3,480	2,729	.301
Coffee, artificial	.80 mark per kilo	2,210	2,563	.362
Herring, weight 135 grams, 50 per cent refuse	.08 mark per piece	174	2,175	.460
Eggs, contents 47 grams	.05 mark per piece	73	1,440	.685
Beef, with 15 per cent bones	1.08 mark per kilo	1,220	963	.885
Coffee, genuine, roasted	2 marks per kilo	950	475	2.105

^a In one kilo, liter, or piece.^b Rice, millet, grits, barley, legumes.

The value of this study of Von Rechenberg's, so far as the accuracy of its results is concerned, is to be judged from two standpoints, namely, the reliability of the statistical information, including especially that regarding food consumption, and the accuracy of the values used for the calculation of composition, digestibility, and potential energy of the food materials.

Concerning the accuracy of the statistical information, it is to be noted that the data were not collected by Von Rechenberg in person, but were furnished by the people whom he was studying.

Von Rechenberg's work, like nearly all thus far done, falls below the ideal in still another respect. No determinations were made of either the composition or the digestibility or the fuel value of the food. All the figures for composition are taken from the compilations of König¹ and other standard authorities. These values are doubtless as close to the facts as are possible without actual analyses.

These estimates of quantities of food, and of nutrients, digestibility and potential energy of the food consumed by the people in Zittau, which are carried out in great detail remind one of the method of estimating distances, which consists in measuring feet by the eye, inches by a foot rule, and fractions of an inch by a micrometer screw, and taking the sum of the figures thus obtained for the actual measure. Nevertheless such computations have their value and are referred to here, not merely as an illustration of the ways in which an investigator who had devoted a great deal of attention to the study of the fuel value of food materials seeks to apply his results, but also as an indication of some of the ways in which accuracy must be sought in future research. When it shall become possible to make experiments in which the income and

¹ *Chemie der Nahrungs- und Genussmittel*, second edition.

outgo shall be accurately weighed, measured, and analyzed, such refinements of computation as those employed by Von Rechenberg may actually come into play.

DIETARIES OF PEOPLE OF THE POORER CLASSES IN NAPLES.

A careful and somewhat extended study of the dietaries of people of the poorer classes in Naples has been recently made by Manfredi.¹ An excellent feature of this investigation is found in the determination of not only the composition of the food consumed, but also the proportions actually digested. In the following account, which is greatly condensed from the original, a number of evident errors in the latter are corrected.

Manfredi is a native Neapolitan and could easily reach the people he desired to study, namely, the small wage earners, the beggars "lazzaroni," and in general those who live from hand to mouth.

Little of the food consumed by this class of people is cooked at home. Small shops—bettole—abound, in which the food is purchased ready cooked. This does not mean that the best food of the kind is sold for a low price as in the German "people's kitchen" (*Volksküche*). The food is really of the poorest quality and the price is relatively high, a meal costing usually from 5 to 30 centesimi (1 to 6 cents). The food of these people contains a larger variety of articles than is usual with the poor classes in Europe. The variety consists in the number of kinds of macaroni and other pastes, and the green vegetables which grow so abundantly in the neighborhood of Naples. Macaroni and bread are, perhaps, the two most important foods.

Macaroni and other forms of flour paste are to the Neapolitan what polenta is to the people of northern Italy and rice is to some of the people of Asia. Sometimes the dough is pressed in flat cakes baked with fat or cheese and tomatoes or with small fresh fish; this cake is called "pizza." Indeed, numerous dishes of this sort are in common use. The bread is almost always white—black bread is rarely seen—and often as much as 1 to 1½ kilos per day is eaten by one person. In times of distress almost the only food is bread. Beef is too expensive to form any considerable part of the diet of the poor. When meat is eaten it is usually mutton in summer and pork in winter. Much oftener, however, the heart, lungs, liver, brains, and the parts which we ordinarily count as refuse are eaten, and dishes in great variety are made from them. It is curious that while fish abound in the waters near Naples, very little is eaten fresh. Sometimes small fishes are seasoned in various ways and fried in fat. On the other hand large quantities of dried and salted fish are eaten, chiefly cod and hake, (*gadus morrhua* and *gadus melucius*).² These are either fried or made into a kind of soup with tomatoes or cooked with oil and vinegar. Milk and eggs are too expensive to be eaten much, and cheese is used

¹ Arch. Hyg., 17, 1893, p. 552.

² *Gadus melucius* (?)—*G. Merluccius*, L., *Merluccius vulgaris*, Günther.

more as a condiment than as an article of food. Rice is too dear to be much employed, but potatoes are abundant especially in summer. Dry beans are used in large and peas in small quantities nearly always for soups. The garden vegetables which are so abundant are cabbage, cauliflower, green salad, tomatoes, carrots, onions, etc. In summer enormous quantities of fruit are eaten, so much that it sometimes seems as if the beggars must live on fruit alone, which of course is not the case. The drink which is almost always used at meal times is a light wine, often so much diluted that it could hardly be called wine.

The author's description of the people and the methods of observation is in substance as follows: Dietaries of 8 individuals were studied. The studies extended from January to July, thus making it possible to observe the effect of different seasons of the year upon the food consumption, a by no means unimportant factor in Naples. The individuals were from the classes of the very poor that make up a large part of the population of Naples. They included (1) workmen of the lower class who prefer light and intermittent labor, such as cobblers, carpenters, masons, and (2) people who are without regular employment and much of the time idle, the wandering creatures who pass the day on the street and live on what chance may bring, such as messengers, peddlers from house to house, and beggars, *lazzaroni*.

During the investigation each individual was very carefully watched. Every precaution was taken to keep them in the laboratory day and night or to have them under surveillance if they went outside, and to make sure they associated only with persons connected with the laboratory and did not come in contact with ordinary companions. In so far as possible each person was provided with occupation of the kind and amount to which he was accustomed. For instance, the mason mended the tile roof of the laboratory; the carpenter worked with a carpenter employed in the Hygienic Institute at that time; old shoes were given to the cobbler to mend, others were employed in various ways in cleaning the laboratory, and even the beggars "who were accustomed to do nothing were provided with their usual employment, which was not a difficult matter." The peddlers, who were accustomed to considerable exercise, found this in climbing the many stairs and walking in the garden of the institute; they were sometimes allowed to walk in the city, being accompanied by a member of the laboratory staff or by Manfredi himself.

In the supply of food the usage of families of the poorer classes in Naples was followed, in that two meals were eaten per day, a hearty one at noon and a light, sometimes a very light, one at night. In some cases, however, the order was reversed, the heartier meal being eaten at night. It should be said that such regularity in eating is by no means universal and rigidly adhered to among the poor people. Very many, particularly those leading a vagrant life, are accustomed to long fasts, followed by eating to excess. Others, particularly women, have no defi-

nite meal times, but nibble at all hours of the day. The latter custom, however, was not permitted in these investigations, both because it is the exception rather than the rule, and because it would have made the number of analyses very great, and thus have increased the chances of error. When the individual could be trusted his satiety was taken as the measure of the amount of food he required. Sometimes the amount was determined from the size of the portions of cooked food furnished and from information obtained at the cookshop where they were accustomed to obtain their food. According to the habit of the individual the midday meal was either prepared at home or purchased ready cooked from a cookshop. In every case one and one-half or two portions were provided, one for the subject and the remainder for analysis. The period of observation for each person was from 3 to 7 days. Each day was reckoned from 8 o'clock in the morning to 8 the next morning. The food between these two hours was regarded as the food for the day.

Specimens of the food of each meal were taken for analysis. The corresponding urine and feces of 24 hours were likewise taken for analysis. It was considered that the portion of the former which belonged to the day of the experiment would be voided during the 24 hours beginning 12 hours after the beginning of the day, i. e., as the experimental day began at 8 a. m. the urine for that day would include what was collected during the 24 hours beginning with 8 p. m. The separation of feces was made with the aid of seed of grapes taken with the last meal before and the first meal after the experimental period. A fasting period of 16 hours was allowed to intervene between the first meal of the experiment and the last preceding, and the same period of fast intervened between the last meal of the experiment and the next succeeding one. With the simple diet of vegetable food to which the people were accustomed the separation was very easy. The analysis of food and excreta were made by the usual methods.

The following table, which is translated literally from the original, shows the statistics gathered in one of the eight cases. Like statistics are given for each of the seven other cases.

The results of the 8 investigations are summed up in the following table:

TABLE 36.—*Summary of statistics of eight dietaries of poor people in Naples.*

Subject.	Food consumed.								
	Weight.	Number of days.	Liquid.	Water-free substance.	Nitrogen.	Protein.	Ether extract.	Carbohydrates and ash.	Sodium chlo-rid.
	<i>Kilos.</i>		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Cobbler	55	5	1,167.4	449.7	11.46	71.62	29.4	348.8	.....
Cobbler	47	5	1,311.6	532.9	12.65	79.06	45.6	408.6	10.8
Old woman, servant	38	3	976.6	412.4	9.31	58.18	19.8	334.4	6.3
Carpenter	62	7	1,377.3	624.9	15	93.75	56.2	475.1	9.4
Young woman, servant....	48	4	1,179.2	425.4	10.06	62.87	19.9	342.8	11.4
Mason	55	5	1,148.8	489.6	11.28	70.49	28.5	390.6	.....
Beggar	50	4	1,271	447.8	10.45	65.28	28.2	354.2	10.8
Peddler (woman).....	52	5	954	385.8	9.72	60.75	27.9	297.2	.....
Maximum.....	.....	.....	1,377.3	624.9	15	93.75	56.2	475.1	11.4
Minimum .....	.....	.....	954	385.8	9.31	58.18	19.9	297.2	6.3
Average	51	.....	1,173.2	471.1	11.24	70.25	31.9	368.9	9.7

Subject.	Feces.							Urine.			Total excreted ni-trogen.
	Liquid.	Water-free substance.	Nitrogen.	Protein.	Ether extract.	Carbohydrates and ash.	Sodium chlo-rid.	Nitrogen.	Protein.	Sodium chlo-rid.	
	<i>Gms.</i>	<i>Gms.</i>	<i>Gms.</i>	<i>Gms.</i>	<i>Gms.</i>	<i>Gms.</i>	<i>Gms.</i>	<i>Gms.</i>	<i>Gms.</i>	<i>Gms.</i>	<i>Gms.</i>
Cobbler	278	33.1	1.71	10.71	4.8	18.6	.....	9.45	59.06	.....	11.16
Cobbler	141.6	33.1	2.19	13.68	7.1	12.3	1.3	10.56	66	9.6	12.75
Old woman, servant	116	21.6	1.32	8.28	1.5	11.7	1.5	7.69	48.08	4.6	9.01
Carpenter	245.9	45.7	3.06	19.09	5.7	20.8	1.1	11.62	72.62	9	14.68
Young woman, servant ...	171.7	39.4	3.14	19.62	3.8	16	.4	6.84	42.75	9.9	9.98
Mason	177.4	38.6	2.97	18.56	2.7	18.4	.....	8.04	50.25	.....	11.01
Beggar	113	22	1.405	8.78	2.1	11.3	.6	9.245	57.78	10.8	10.65
Peddler (woman).....	153	24.8	1.57	9.81	3.8	11.1	.....	8.05	50.31	.....	9.62
Maximum.....	278	45.7	3.14	19.62	7.1	20.8	1.5	11.62	72.62	10.8	14.68
Minimum	113	21.6	1.32	8.28	1.5	11.1	.4	6.84	42.75	4.6	9.01
Average	178.3	32	2.17	13.50	3.9	15	1	8.937	55.85	8.8	9.15

TABULAR STATEMENTS OF RESULTS OF DIETARY STUDIES.

In Table 37, which follows, the final results of the 138 selected studies of dietaries, mentioned on page 144 above, are recapitulated. It was thought desirable to classify these dietaries by countries rather than by classes of people and occupation.

TABLE 37.—*Foreign and American dietaries.*

[Quantities per man per day.]*

Reference No.	Dietaries.	Number of persons.	Nutrients.			Potential energy.	Nutritive ratio.
			Protein.	Fats.	Carbohydrates.		
	FOREIGN. (EUROPEAN, JAPANESE, AND JAVANESE.)						
	ENGLAND.		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories</i>	<i>1:</i>
1	Well-fed tailors (prisoners)	2	131	39	525	3,055	4.7
2	Hard-worked weavers (prisoners)	2	151	43	622	3,570	4.8
3	Royal engineers, at active work.....	495	144	83	631	3,950	5.7
	DENMARK.						
4	Physician, 37 years old, Copenhagen.....	1	135	140	250	2,880	4.2
5	Principal of school, 35 years old, wife of No. 4..	* 1	95	107	220	2,285	4.9
	SWEDEN.						
6	Medical students, 22 to 27 years of age, Stockholm	5	127	114	300	3,035	4.8
7	Mechanics, etc., at moderate work, southern Sweden, average of 6 individual dietaries	6	134	79	¹ 523	3,435	5.2
8	Mechanics, etc., at severe work, southern Sweden, average of 5 individual dietaries	5	189	110	² 714	4,725	5.1
	RUSSIA.						
9	Factory operatives, near Moscow, average of 9 families	(*)	106	49	488	2,890	5.7
10	Factory operatives, near Moscow, average of 50 boarding clubs composed of men	³ 2,670	132	80	584	3,680	5.8
11	Factory operatives, near Moscow, average of 10 boarding clubs composed of women and boys ..	* ³ 234	98	51	487	2,875	6.1
12	Peasants near Moscow, average of men's dietaries		129	33	589	3,250	5.1
13	Peasants near Moscow, average of women's dietaries	(*)	102	28	471	2,610	5.2
	GERMANY.						
	1. Scantily nourished.						
14	Laborer's family, father, mother, and child 6 years old	3	52	32	287	1,690	6.9
	WORKING PEOPLE IN LEIPSI, SAXONY.						
15	Girl in factory, wages \$1.20 (5 marks) per week, pale and sickly, food mostly bread and potatoes, half a pound of meat per week, cost of food 8.2 cents per day	* 2	52	53	301	1,940	8.1
16	Girl in printing office, wages \$1.20 per week, food similar to preceding, cost 10.3 cents per day.....	* 2	65	39	303	1,870	6
17	Widow, straw plaiter, with 5 children, food mostly bread and potatoes, occasionally meat, cost of food 9.6 cents per day.....	* 6	72	56	440	2,620	7.9
18	Two girls, one 24 years old, in paper factory, wages \$2.16 (9 marks), the other 21 years, seamstress, wages \$1.92 (8 marks); cost of food 8.6 cents per day.....	* 3	56	51	229	1,645	6.2
19	Girl, 18 years old, in book-bindery, wages \$2.16 per week, cost of food 8.6 cents per day.....	* 1	61	41	347	2,055	7.2
20	Painter, wages \$4.32 per week, unmarried, cost of food 11.5 cents per day.....	1	87	64	366	2,450	5.9
21	Cabinetmaker, with wife and 6 children, wages \$1.92 per week, cost of food 11 cents per day..	8	77	57	466	2,760	7.7
22	Druggist's clerk, with wife and 2 children, annual income \$283 (1,180 marks), very little physical exercise, cost of food 11.3 cents per day ..	* 4	71	69	351	2,370	7.1
23	Farm laborer near Leipsic, with wife and 4 children, food mainly vegetable, cost of food 7.2 cents per day.....	6	80	37	504	2,740	7.4

* Quantities per person per day.

¹ Including 22 grams alcohol. 1 gram alcohol = 1.71 grams carbohydrates.² Including 24.2 grams alcohol.³ An approximate estimate.

TABLE 37.—*Foreign and American dietaries—Continued.*

Reference No.	Dietaries.	Number of persons.	Nutrients.			Potential energy.	Nutritive ratio.
			Protein.	Fats.	Carbohydrates.		
	WORKING PEOPLE IN LEIPSI, SAXONY—cont'd.						
24	Farm laborer, Prussia, very poor, diet mostly vegetable.....	3	Grams. 83	Grams. 17	Grams. 573	Calories 2,845	1: 7.4
25	Laboring woman of poorer class, Munich, vigorous, but at rather hard work, food hardly adequate.....	* 1	76	23	334	1,895	5.1
26	Hand weavers, Zittau, Saxony, average of adults in 28 families.....	1 * 56	65	49	485	2,705	9.2
	Average, Nos. 14 to 26.....	* 96	69	45	384	2,275	7
	2. Prisoners.						
27	Inmates of Badstrasse prison in Munich, doing no work.....	(*)	87	22	305	1,810	4.1
28	Inmates of prison in Brandenburg, without work.....	(*)	109	34	574	3,115	6
29	Inmates of house of correction in Munich, at work.....		104	38	521	2,915	5.8
30	Inmates of house of correction in Brandenburg, at work.....		127	29	639	3,410	5.5
	3. People not having active exercise.						
31	Inmates of house for old women in Munich (Pfründneranstalt).....	(*)	80	49	266	1,875	4.7
32	Inmates of house for old men and women in Munich (Pfründneranstalt).....	* 477	92	45	332	2,155	4.7
33	Man at rest, average of 3 tests in respiration apparatus.....	1	137	72	352	2,675	3.8
34	Physician, 31 years old (Professor Beneke), Oldenburg, diet not quite sufficient to maintain bodily condition.....	1	90	79	285	2,270	5.2
35	Same, diet estimated sufficient for normal maintenance.....	1	94	109	284	2,565	5.6
36	Professor Ranke, Munich, in respiration apparatus.....	1	100	100	240	2,325	4.7
37	Same, food slightly different from No. 36.....	1	126	85	213	2,180	3.2
38	Lawyer, Munich.....	3	80	125	222	2,400	6.3
39	Young physician, Munich.....	1	127	89	362	2,835	4.4
40	Young physician, Munich.....	1	134	102	292	2,695	3.9
	Average of Nos. 35 to 40, 6 dietaries of well-to-do professional men, food largely animal.....	8	110	102	269	2,505	4.5
41	Official in civil service, a vegetarian.....	1	74	58	490	2,850	8.4
	4. People with more or less active muscular work.						
42	Mechanic in comfortable circumstances at light work, 60 years old, Munich.....	1	117	68	345	2,525	4.3
43	Shoemaker, Rostock.....	1	108	77	378	2,710	5.1
44	Upholsterer, a strict vegetarian, 28 years old, Munich.....	1	54	22	573	2,775	11.5
45	Well-paid mechanics, Munich.....	3	151	54	479	3,085	4
46	Carpenters, coopers, locksmiths, Bavaria, average of 11 dietaries.....		122	34	570	3,150	5.3
47	Porter, Munich, 36 years old, unmarried.....	1	133	95	422	3,160	4.8
48	Cabinetmaker, 40 years old, Munich.....	1	131	68	494	3,195	5
	Bavarian mechanics, etc., at moderate work, average of Nos. 45 to 48.....		134	63	491	3,150	4.7
49	Farm laborers, Bavaria, average of 5 dietaries.....		137	55	542	3,295	4.9
50	Miners at severe work, Prussia.....	4	133	113	634	4,195	6.7
51	Brewery laborers, Bavaria, average of 5 dietaries.....		149	61	755	4,275	6
52	Brickmakers (contract laborers from Italy) near Munich; diet, maize meal and cheese. ...	300	150	94	683	4,290	6
53	Machinists, etc., Krupp gun works, Essen.....	800	139	113	677	4,395	6.7

* Quantities per person per day.

¹ This average is reduced to terms corresponding to a person weighing 57 kilos (125 pounds), the average weight of all the men and women of the families.

TABLE 37.—*Foreign and American dietaries*—Continued.

Reference No.	Dietaries.	Number of persons.	Nutrients.			Potential energy.	Nutritive ratio.
			Protein.	Fats.	Carbohydrates.		
	WORKING PEOPLE IN LEIPSI, SAXONY—cont'd.						
	4. <i>People with more or less active muscular work</i> —Continued.						
54	Farm laborers, Bavarian highlands, large, muscular men at severe work, average of 3 dietaries.....	3	Grams. 137	Grams. 202	Grams. 546	Calories 4,680	1: 7.3
55	Lumbermen, Bavarian highlands, large, muscular, vigorous, doing heavy work in rigorous climate, average of 3 dietaries.....	3	130	292	724	6,215	10.7
56	German army ration, peace footing.....		114	39	480	2,800	5
57	German army ordinary ration, war footing.....		134	58	489	3,095	4.6
58	German army extraordinary ration, in war.....		192	45	678	3,985	4.1
59	German army extraordinary ration, Franco-German war.....		157	285	331	4,650	6.2
	AUSTRIA.						
60	Farm laborers, Transylvania, at harvesting; diet, maize meal and beans.....	15	159	62	977	5,235	7
	ITALY.						
	<i>Poor people in Naples, lower class.</i>						
61	Mechanics, etc., average of 5 dietaries.....	5	76	38	396	2,290	6.3
62	Servants, etc. (women), average of 5 dietaries..	*3	61	23	325	1,795	6.2
63	Peasant, farm laborer, near Ferrara, average of winter and summer dietaries.....	1	118	65	628	3,665	6.6
64	Wife of No. 63, average of winter and summer dietaries.....	*1	95	54	499	2,940	6.5
65	Son of Nos. 63 and 64, 14 years old, average of winter and summer dietaries.....	*1	67	39	332	2,000	6.3
66	Italian army ration, peace footing.....		114	14	592	3,025	5.5
	FRANCE.						
67	Physician, 48 years old.....		92	61	235	1,910	4.1
	CHILDREN (GERMANY, RUSSIA, AND SWITZERLAND).						
68	Under 2 years old, average of 3 individual dietaries.....	*3	27	20	115	770	5.9
69	From 2 to 6 years old, average of 14 individual dietaries.....	*14	53	42	155	1,245	4.7
70	From 6 to 10 years old, average of 8 individual dietaries.....	*8	65	45	217	1,575	4.9
71	From 10 to 14 years old, average of 13 individual dietaries.....	*13	72	50	249	1,780	5
72	Children, 6 to 15 years old, in orphan asylum, Munich.....	(*)	79	37	247	1,680	4.2
73	Boys, 8 to 15 years old, in children's home at Gehlsdorf, near Rostock.....	*38	87	50	508	2,905	7.1
74	Girls, 14 to 19 years old, Krupp industrial school, Essen.....	*71	101	75	415	2,815	5.8
	JAPAN.						
75	Prisoners without work, Tokyo.....	(*)	48	7	372	1,785	8.1
76	Prisoners at work, Tokyo, average of 2 dietaries.....	(*)	66	9	544	2,585	8.5
77	Employees in retail store, Tokyo.....	*72-85	55	6	394	1,895	7.4
78	Y. Mori, assistant in University of Tokyo; dietary of self (ordinary diet with meat).....	1	123	21	416	2,405	3.8
79	Students, Kioto, average of 2 individual dietaries.....	2	98	16	438	2,345	4.8
80	Cadet school at Tokyo.....	(*)	83	14	631	3,060	8
81	Government school, Tokyo; pupils, 17 to 25 years old.....	*130	115	30	635	3,355	6.1
82	Private school in Tokyo; pupils, 11 to 21 years old.....	*21	79	13	470	2,370	6.3
	JAVA.						
83	Java village, World's Fair, Chicago.....	5	66	19	254	1,490	4.5

* Quantities per person per day.

TABLE 37.—*Foreign and American dietaries—Continued.*

Reference No.	Dietaries.	Number of persons.	Nutrients.			Potential energy.	Nutritive ratio.
			Protein.	Fats.	Carbohydrates.		
	AMERICAN (UNITED STATES AND CANADA). ¹						
	SERIES A.—MISCELLANEOUS, FACTORY OPERATIVES, MECHANICS, ETC., MASSACHUSETTS.						
	Boarders, operatives in cotton mills:		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories</i>	<i>1:</i>
84	Boarding house, Lowell.....	77	132	227	545	4,890	8
85	Boarding house, Lowell.....	70	132	200	594	4,650	7.6
86	Boarding house, Lowell.....	150	105	136	477	3,650	7.5
87	Boarding house, Lynn, shoe factory operatives, dressmakers, clerks, etc.....	36	114	150	522	4,000	7.5
88	Boarding house, Lawrence, mill operatives....	80	127	195	523	4,480	7.6
89	Family, East Cambridge, father glass blower..	6	95	132	481	3,590	8.2
90	Family, Boston, husband, machinist.....	2	182	254	617	5,640	7.6
	Average.....	421	127	185	531	4,415	7.5
91	Boarding house, Boston, teamsters, marble workers, etc., at severe work.....	12	254	363	826	7,805	6.5
92	Boarding house, brickmakers, at severe work..	237	180	365	1,150	8,850	11
	Average.....	670	147	225	632	5,285	7.8
93	} French Canadian families, in North Cambridge, fathers, brickmakers, at severe work.....	4	132	236	750	5,810	9.7
94		5	100	173	545	4,250	9.4
95		5	95	145	514	3,845	8.9
	Average.....	14	109	185	603	4,635	9.3
	SERIES B.—FRENCH CANADIANS, FACTORY OPERATIVES, MECHANICS, ETC., MASSACHUSETTS.						
96	Family, Lawrence, mill operatives.....	6	114	186	522	4,340	8.3
97	Boarding house, Holyoke, operatives in paper mills.....	18	95	268	327	4,220	9.8
98	Boarding house, Holyoke, factory operatives..	10	141	268	554	5,340	8.2
99	Family, Holyoke, mill operatives.....	6	82	132	495	3,595	9.7
100	Family, Worcester, mill operatives.....	10	114	127	504	3,715	6.9
101	Family, Worcester, father, printer.....	4	118	177	509	4,215	7.7
102	Family, Lowell, blacksmiths at hard work.....	3	200	304	795	6,905	7.4
	Average.....	57	123	209	529	4,620	8.2
	Average.....	71	119	202	552	4,625	8.5
	SERIES C.—FRENCH CANADIANS, CANADA, ALL LABORING PEOPLE.						
103	Boarding house, Montreal.....	8	100	77	573	3,475	7.5
104	Family, Montreal.....	3	141	177	723	5,190	8
105	Family, Quebec.....	8	132	100	513	3,575	5.6
106	Family, Quebec.....	8	136	127	641	4,365	6.8
107	Family, St. John.....	5	123	114	582	3,950	6.8
108	Family, St. John.....	10	82	91	431	2,950	7.8
109	Boarding house, Sorel.....	10	91	73	514	3,160	7.5
110	Boarding house, Sorel.....	12	86	86	473	3,090	7.8
111	Boarding house, Riviere du Loup.....	15	73	86	386	2,680	8
112	Family, St. Hyacinth.....	6	105	86	468	3,150	6.4
113	Family, Sherbrooke.....	4	150	168	536	4,375	6.1
114	Family, Richmond.....	8	86	91	477	3,155	7.9
115	Family, Richmond.....	5	104	100	522	3,495	7.2
	Average.....	102	108	106	526	3,585	7.1
	CONNECTICUT. ²						
116	Family of chemist.....	5	118	103	430	3,205	5.6
117 a	Family of college professor:						
	Food purchased.....	4	129	183	467	4,145	6.8
117 b	Food eaten.....	4	128	177	466	4,080	6.8

¹ Collated by Massachusetts Labor Bureau.² With the exception of Nos. 118 and 119 all Connecticut dietaries are in Middletown.

TABLE 37.—*Foreign and American dietaries—Continued.*

Reference No.	Dietaries.	Number of persons.	Nutrients.			Potential energy.	Nutritive ratio.
			Protein.	Fats.	Carbohydrates.		
	CONNECTICUT—continued.						
	Family of college professor, Storrs:						
	Winter dietary, January and February—		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories</i>	<i>1:</i>
118 a	Food purchased	3	106	145	405	3,450	6.9
118 b	Food eaten	3	99	139	398	3,335	7.2
	Summer dietary, July—						
119 a	Food purchased	2	133	130	475	3,885	6.1
119 b	Food eaten	2	129	145	472	3,800	6.2
	Family of a retired merchant, son chemist:						
120 a	Food purchased	4	91	126	483	3,530	8.5
120 b	Food eaten	4	83	117	478	3,390	9
	Averages of Nos. 116 to 120; families of well-to-do professional men—						
	Food purchased	18	115	141	452	3,635	6.7
	Waste	18	4	5	3	75	.....
	Food eaten	18	111	136	449	3,560	6.8
	M. club, college students; 3 dietaries of same club:						
	First dietary—						
121 a	Food purchased	24	161	204	680	5,345	7.1
121 b	Food eaten	24	138	184	622	4,825	7.5
	Second dietary—						
122 a	Food purchased	31	115	163	460	3,875	7.2
122 b	Food eaten	31	104	136	421	3,415	7
	Third dietary—						
123 a	Food purchased	27	113	180	376	3,680	6.9
123 b	Food eaten	27	92	141	346	3,110	7.2
	N. club, college students:						
124 a	Food purchased	3	141	160	503	4,130	6.1
124 b	Food eaten	3	140	158	503	4,105	6.2
	Students' club, divinity school:						
125 a	Food purchased	30	139	185	356	3,745	5.6
125 b	Food eaten	30	122	138	317	3,085	5.2
	Average of Nos. 121 to 125; boarding clubs of college and professional students—						
	Food purchased	115	134	178	475	4,155	6.6
	Waste	115	15	27	34	450	.....
	Food eaten	115	119	151	441	3,705	6.6
	Average of Nos. 116 to 126, professional men and students—						
	Food purchased	133	125	160	464	3,905	6.6
	Waste	133	10	16	19	270	.....
	Food eaten	133	115	144	445	3,635	6.7
	College football team:						
126 a	Food purchased	12	194	312	578	6,070	6.6
126 b	Food eaten	12	181	292	557	5,740	6.7
	Boarding house, well-paid machinists, etc.:						
127 a	Food purchased	21	126	188	426	4,010	6.8
127 b	Food eaten	21	103	152	402	3,485	7.3
	Family of a machinist:						
128 a	Food purchased	5	100	159	427	3,640	7.9
128 b	Food eaten	5	99	156	421	3,580	7.8
	Family of a blacksmith:						
129 a	Food purchased	4	103	176	408	3,730	7.8
129 b	Food eaten	4	100	171	401	3,640	7.9
	Family of a stone mason:						
	Winter dietary, December—						
130 a	Food purchased	3	107	153	391	3,470	6.9
130 b	Food eaten	3	104	148	375	3,350	6.9
	Spring dietary, April—						
131 a	Food purchased	3	125	145	366	3,365	5.6
131 b	Food eaten	3	119	137	348	3,190	5.5
	Family of a carpenter:						
132 a	Food purchased	3	125	152	498	3,970	6.7
132 b	Food eaten	3	114	135	475	3,670	6.9
	Family of a carpenter:						
	Winter dietary, December—						
133 a	Food purchased	3	107	161	408	3,610	7.2
133 b	Food eaten	3	100	149	388	3,390	7.9

TABLE 37.—*Foreign and American dietaries*—Continued.

Reference No.	Dietaries.	Number of persons.	Nutrients.			Potential energy.	Nutritive ratio.
			Protein.	Fats.	Carbohydrates.		
	CONNECTICUT—continued.						
	Family of a carpenter—Continued.						
	Spring dietary, May—		Grams.	Grams.	Grams.	Calories	1:
134 a	Food purchased.....	3	115	125	346	3,055	5.5
134 b	Food eaten.....	3	111	122	336	2,965	5.5
	Average of Nos. 127 to 134; wage-workers—						
	Food purchased.....	45	114	157	409	3,605	6.7
	Waste.....	45	8	11	16	200	.....
	Food eaten.....	45	106	146	393	3,405	6.8
	PENNSYLVANIA.						
135	Miscellaneous families in poorest part of Philadelphia. Dietaries of 25 families:						
	Average.....		109	108	435	3,235	6.2
	Minimum (negro)		66	68	181	1,630	5.4
	Maximum (German).....		202	206	608	5,235	5.3
	ILLINOIS.						
136	Miscellaneous families in poorest part of Chicago. Dietaries of 26 families:						
	Average.....		119	141	398	3,425	6
	Minimum		86	100	213	2,195	4.6
	Maximum.....		168	204	626	4,950	11.3
137	United States army ration		120	161	454	3,850	6.8
138	United States navy ration.....		143	184	520	5,000	7.5

Nos. 1 to 3, Playfair, Chem. News, 1865 (XI), 221.

Nos. 4 and 5, Jürgensen, Ztschr. Biol., 1886, 489.

Nos. 6 to 8, Hultgren and Landergrén, No. 6, Untersuchung über die Ernährung bei frei gewählter Kost, Hygiea, 1889; Festband No. 11, and Nos. 7 and 8, Untersuchung über die Ernährung schwedischer Arbeiter, Stockholm, 1891.

Nos. 9 to 11, Erismann, Arch. Hyg., 1889 (9), 23.

Nos. 12 and 13, Sarin, Ibid., 34.

No. 14, F. Hofmann, Ztschr. physiol. Chem., VI (1882), 372.

Nos. 15 to 23, Meinert, Armee und Volks-Ernährung, II, 189-221.

No. 24, Böhm, Meinert, II, 186.

No. 25, Forster, Untersuchung der Kost, 211.

No. 26, Von Rechenberg, Die Ernährung der Handwerker, Leipsic, 1890.

Nos. 27 and 29, Schuster, Untersuchung der Kost, 165, 146.

Nos. 28 and 30, Richter, Ibid., 174.

Nos. 31 and 32, Forster, Ibid., 189, 191; Ztschr. Biol., 1873, 401.

No. 33, Pettenkofer and Voit, Ztschr. Biol., 1866 (2), 459.

Nos. 34 and 35, Beneke, Zur Ernährungslehre d. ges. Mensch., Cassel, 1878, 290.

Nos. 36 and 37, Ranke, Die Ernährung d. Menschen, 193, 230.

No. 38, Forster, Untersuchung der Kost, 213.

Nos. 39 and 40, Forster, Ztschr. Biol., 1873, 389, 390.

No. 41, Cramer, Ztschr. physiol. Chem., VI (1882), 346.

No. 42, Forster, Untersuchung der Kost, 208.

No. 43, Hoch, Dissertation. Rostock, 1888; Ref. Handbuch der Hygiene, Weyl., III, 1, 84.

No. 44, Voit, Ztschr. Biol., 1889, 232.

No. 45, Voit, Untersuchung der Kost, 28.

Nos. 46, 49 and 51, report of Royal Bavarian special commission, see Meinert, II, 225.

Nos. 47 and 48, Forster, Ztschr. Biol., 1873, 387, 388.

No. 50, Steinheil, Ztschr. Biol., 1877, 415.

No. 52, Ranke, Ibid., 130.

No. 53, Prausnitz, Arch. Hyg., 15 (1892), 387.

No. 54, Höfler, Der Isarwinkel, Munich, 1891, 63-72.

No. 55, Höfler, Ibid., and Liebig, Meinert, II, 224; Sitzungsber. d. bayr. Acad., II, 463, 1869; Reden u. Abhandl., 121.

Nos. 56 to 59, Meinert, Armee und Volks-Ernährung, I, 276-287; and König, third edition, I, 156.

No. 60, Ohlmüller, Ztschr. Biol., 1884, 393.

Nos. 61 and 62, Manfredi, Arch. Hyg., 17 (1893), 552.

Nos. 63 to 65, Albertoni and Novi, Arch. Physiol., 1894, 213.

No. 66, Moleschott, Razione del Soldato Italiano, Rome, 1883.

No. 67, Beaunis, Recherches Expér., Paris, 1884, 4; Ref. Handbuch der Hygiene, Weyl., III, 1, 84.

- Nos. 68 to 71, Forster, *Ztschr. Biol.*, 9 (1873), 381. Camerer, *Ibid.*, 1880, 24; 1882, 220; 1884, 556; 1888, 141; 1893, 227, 398. Uffelmann, *Ibid.*, 1882, 584. Hasse, *Ibid.*, 1882, 553.
 No. 72, Voit, *Untersuchung der Kost*, 125.
 No. 73, Schröder, *Arch. Hyg.* 4 (1866), 39.
 No. 74, Prausnitz, *Ibid.*, 15 (1892), 387.
 Nos. 75, 76, and 80, Eijkman, *Ztschr. Biol.*, 1889, 106.
 Nos. 77, 81, and 82, Tawara, *Ibid.*, 1889, 107; *Arch. Hyg.*, 1888, 102.
 No. 78, Kellner and Mori, *Ztschr. Biol.*, 1889, 102.
 No. 79, Scheube, *Arch. Hyg.*, 1883, 352.
 No. 83, Atwater and associates.
 Nos. 84 to 115, Atwater and assistants. Food consumption; Seventeenth Annual Report Massachusetts Bureau of Statistics of Labor. Report of Storrs (Conn.) Experiment Station for 1891, 106.
 Nos. 116 to 134, and 137 and 138, Atwater and associates, Reports of Storrs (Conn.) Experiment Station, 1891, 106; 1892, 135; 1893, 174.
 Nos. 135 and 136, Shapleigh. A Study of Dietaries; Partial Report of Dutton Fellow, College Settlements Association, 1892-93.

COMMENTS UPON DIETARIES SUMMARIZED IN TABLE 37.

In the belief that the figures of Table 37 will be best understood by statement of some of the more important details, an attempt to recapitulate the latter is made in the pages which follow.

English dietaries.—Nos. 1, 2, and 3 are those estimated by Sir Lyon Playfair from the actual weights of the food consumed by individuals; Playfair speaks of the engineers (soldiers) of No. 11 as “laborers in time of peace actively occupied either in the construction of field works, or pursuing their avocations as artisans,” and regards the dietary as “the most complete evidence we possess [at the time, 1864-1865] of the requirements of food for laboring men doing a fair but not excessive amount of work in 24 hours; when these soldiers are at light labor they are found to take less.” The sailors of No. 1 and weavers of No. 2 were prisoners in the Wakefield Gaol. The details of food consumption were very carefully observed, and are published by Dr. E. Smith.¹

Danish and Swedish dietaries.—Nos. 4 and 5 are reported by Jürgesen. No. 4 is that of a physician in Stockholm, 37 years old. The food in this case, as in No. 5, consisted of milk, meat, fish, bread, cheese, butter, and beer. The investigation was made in January and February. No. 5 is that of the wife of the physician just named, 35 years old, principal of a girls' school; time of investigation, May. The food actually eaten was weighed and its composition estimated from the compilations of König and Almen.

Nos. 6, 7, and 8 are reported by Hultgren and Landgren. The food materials were carefully weighed as used; the composition was estimated from analyses published by König and Almen. For substances of which no reliable figures for composition were available, as pastry, etc., special analyses were made.

No. 6 represents the average of 5 dietaries of as many medical students in Stockholm, from 22 to 27 years of age, busily engaged in study and laboratory work. The examinations were made in the winter. The experimental periods ranged from 8 to 16 days; the protein per person per day from 103 to 163 grams, and the energy from 2,800 to 3,375 calories.

No. 7 represents the average of 6 dietaries of 4 healthy men, a metal worker, a blacksmith, a carpenter, and a farm laborer, from 28 to 46 years of age, at moderately hard work and earning good wages. The food included meat, fish, milk, etc., and alcohol in beer or stronger spirits. The alcohol averaged 22 grams per man per day, and is estimated as equivalent in fuel value to 37.8 grams of carbohydrates. The protein ranged from 105 to 166 grams and the energy from 2,895 to 3,510 calories per man per day. The diet of this group of men is regarded by the authors as characteristic in respect to nutrients and energy for Swedish laboring men at moderate work (*mittlere Arbeit*).

No. 8 represents the average of 5 dietaries of 5 vigorous men, a stone mason, a bricklayer, a carpenter, a wood sawyer, and a farm laborer, from 31 to 54 years of

¹Phil. Trans., vol. 151, 747.

age, at very hard work, and earning good wages. The food was similar to that of No. 7. The alcohol averaged 24.2 grams per man per day. It was estimated as equivalent to 41.3 grams of carbohydrates, and included in the estimates of carbohydrates and energy as in No. 7. The protein ranged from 128 to 246 grams, and the energy from 3,655 to 5,580 calories per man per day. The authors regard the diet of this group of men as fairly representative of that of Swedish workingmen at severe work.

Russian dietaries.—Nos. 9, 10, and 11 are dietaries of factory operatives in the neighborhood of Moscow, reported by Erismann. It is the general custom of Russian factory operatives, such as are represented in these studies, to board in clubs of their own organization. The purchasing of food, etc., is delegated to a committee, which also keeps a careful account of the number of meals eaten by each member of the club. These accounts are kept with the greatest care, as all the bills are paid by the owners of the factory, and a sum proportional to the number of meals eaten by each member of the club deducted from his wages. The statistics upon which these dietaries are based are derived from these accounts, and represent the quantities of food purchased during periods of from two to three months in length. Their food consists principally of black bread, buckwheat grits, and sauerkraut, and during those parts of the year when fasts are not observed, meat and animal fats. During the fasts, which cover a considerable part of the year, vegetable oils are used to a considerable extent. The composition of the food was estimated principally from previous analyses by Russian observers, otherwise according to König's compilations.

Nos. 12 and 13 are dietaries of peasants in the same locality, by Sarin. Each study occupied one week. The food actually eaten by each person at each meal was carefully weighed; the composition was estimated.

German dietaries.—No. 14 is the dietary of the family of an intelligent laboring man, who had not been able to obtain work for several months, and was almost destitute at the time of the inquiry. The study was made by F. Hofmann.

Nos. 15 to 23 are dietaries of laboring people of the poorer classes, living, No. 23 near, and the rest in the city of Leipsic, Saxony. The inquiry was conducted in part, at least, and presumably the whole, in 1878-1880, by Dr. Meinert, with the purpose of learning something of the conditions of life, and especially the food of people of small incomes in Germany. It was evidently conducted with no little care and thoroughness. For each dietary the food was weighed during a period of five or seven days, with such detail as to show the amounts of each food material per meal. Allowance was made for the waste in one case, at any rate, as stated in the report and presumably for all, so that the quantities given appear to be those actually consumed. No statement is made of analyses especially executed for the investigation, and it is to be inferred that the composition of the food was estimated from standard analyses. The quantities of nutrients and costs of food are estimated per adult per day. In the cases where there were children the equivalent number of adults was assumed for the calculations. The amounts of food of different kinds eaten per meal and per day, the amounts and costs of the several kinds of food, and of the whole food of each dietary, the incomes of the people, and their ways of living, were observed and reported. While the quantities of nutrients imply straitened circumstances in most of the cases, the details in some are decidedly pathetic. The space here will allow only a brief summary of some of the more important points.

No. 15, girl in cigar factory, 25 years old, earning an average of 5 marks per week, and boarding with her mother, who earned 3 marks per week by washing. Their food consisted mainly of bread, potatoes, a little rice, occasionally vegetables, meat 250 grams for 2 persons twice a week, or half a pound a week for each person, and coffee. In lack of fuel for heating the coffee, hot water from a neighboring factory was used. The description says "it is not strange that with food so poor in protein both mother and daughter are frail and sickly, nor that, as the girl told me in tears,

they often went supperless to bed. * * * The girl is the mother of a child 6 months old. * * * For board and lodging of herself and child she pays $3\frac{1}{2}$ marks per week, and thus has left from her wages for clothing and other expenses for herself and child $1\frac{1}{2}$ marks per week, a sum which, while it does not justify, explains her increasing it by other means." The amounts and composition of the food are computed for the young woman and her mother, so that the figures represent the average for the two.

No. 16, girl working in a printing office. She was 29 years old, her wages averaged 5 marks per week, she lived with another girl and a child of the latter in a room 10 feet square. In the three winter months of 1879-80, she had only bread and butter and coffee, and for dinner daily from $1\frac{1}{4}$ to $2\frac{1}{2}$ cents' worth of sausage, and even on this fare used up \$5.50 of previous savings. The amount, composition, and cost of the food were estimated for the two girls together, so that the figures represent the average. "What wonder," says Dr. Meinert, "that young women, whose moral energy and intellectual powers are reduced by such a starvation diet, are unable to withstand temptation."

No. 17, widow, with five children, aged $5\frac{1}{2}$, 8, 10, 12, and 14 years, respectively. She supported herself and children by plaiting straw and taking boarders. The food consisted of bread, beef fat, potatoes, vegetables, and occasionally meat. Family estimated equivalent to 4 adults.

Nos. 18 and 20. No. 18, girl, 24 years old; in paper factory; wages, 9 marks; sister, 21 years; seamstress; wages, 8 marks per week. No. 20, brother of preceding, 28 years old; printer; wages, 18 marks per week. These persons lived with their invalid mother in a fifth-story apartment, consisting of a living room, a sleeping room, and kitchen. Dr. Meinert says that with their earnings these people might have had much better food. "The appearance of the two girls, however, explained the scantiness of their diet. Their clothing, especially that of the seamstress, was much finer than their position and income warranted, and formed a sadly striking contrast to the appearance of the mother and the pitiable dwelling in which the people lived. The food included meat daily. Account was taken of the food of the man and of that of the women separately, the man having more than the women.

Nos. 19 and 21. No. 21, family of cabinetmaker, consisting of father and 6 children, aged $\frac{1}{2}$, 3, 7, 9, 11, and 14 years, and father's sister (No. 19), a girl of 18, working in a bookbindery. The cabinetmaker earned 18 marks and the sister 9 marks per week. The 9 persons lived in an apartment consisting of 2 rooms and a closet holding a cook stove. The sister paid for lodging, breakfast, and dinner $3\frac{1}{2}$ marks (84 cents) per week and purchased bread and butter extra. The wife and children were undersized, pale, and weakly.

No. 22, family of druggist's clerk, consisting of father, mother, and 2 daughters, aged 16 and 12. They are spoken of as thoroughly good people. The annual income was 1,180 marks. Their food was better than the preceding. It included more variety; vegetables, butter, and meat were eaten daily; indeed the family had meat, eggs, or cheese once and often twice a day. As the man's labor was light, Dr. Meinert regards his diet as sufficient for his needs.

No. 23, family of farm laborer near Leipsic, consisting of father, mother, and 4 children, from 5 to 14 years old. The 6 persons are accounted as equivalent to 4 adults. The food consisted mainly of bread, beef fat, and potatoes, with a little milk, and for one meal in the week, Sunday dinner, meat.

The final statistics are summarized in the following table:

Food materials and costs per adult per day.

Reference No.	Dietaries.	Food materials.	Nutrients.				Cost.	
			Protein.		Fats.	Carbohy- drates.		
			Total.	Diges- tible.				
		Grams.	Grams.	Grams.	Grams.	Grams.	Pfennig.	Cents.
15	Girl in cigar factory.....	839	52	42	53	301	34	8.2
16	Girl in printing office.....	1,202	65	54	39	303	43	10.3
17	Woman at straw plaiting.....	1,504	72	56	56	440	40	9.6
18	Girl in paper factory and seam- stress.....	842	56	47	51	229	36	8.6
19	Girl in bookbindery.....	1,062	61	49	41	347	36	8.6
20	Printer.....	1,195	87	73	64	366	48	11.5
21	Cabinetmaker.....	1,271	77	62	57	466	46	11
22	Druggist's clerk.....	1,129	71	59	69	351	47	11.3
23	Farm laborer.....	1,394	80	61	37	504	30	7.2

No. 26, hand weavers in Zittau, Saxony. For detailed description see pp. 164-177.

No. 27 to 30 are dietaries of prisoners in Munich reported by Schuster, and in Brandenburg, Prussia, by Richter. No. 27 is that of a house of detention and No. 28 of a house of correction in Munich; in the latter the terms of service were 3 years or longer with labor. No. 29 is the ration served to prisoners without work, and No. 30 that of inmates of a house of correction, with labor, in Brandenburg. In all the prison dietaries the food was mostly vegetable, and in Munich it was notably insufficient in quantity. In Nos. 27 and 28 the rations were carefully weighed and analyzed. In Nos. 29 and 30 the rations were weighed as prepared for cooking, but no analyses were made.

Nos. 31 and 32 are reported by Forster, and are the dietaries of inmates of infirmaries in Munich for aged and infirm persons in part or wholly incapable of self support. In Nos. 31 and 32 and in all of Forster's dietaries all the food was carefully weighed and samples taken for a more or less complete analysis. When actual analyses were not made the composition was estimated from analyses by Voit and others.

No. 33 is the average of three tests in the respiration apparatus made by Pettenkofer and Voit. The subject was a watchmaker in Munich, 28 years of age, and weighing 70 kilograms (152 pounds). During the experiments he did no muscular work and lived upon an ordinary mixed diet. The quantities of nutrients are those actually metabolized.

Nos. 34 and 35 represent observations by Professor Benecke, of the University of Marburg, upon himself. He was in decidedly active mental and light physical work, had about 3 hours' exercise in the laboratory and 8 hours' sleep. With a mixed diet of meat, milk, bread, etc., containing the nutrients of No. 34, his weight decreased 451 grams (1 pound) during an experiment of 14 days. From determinations of nitrogen in food and excreta, he estimated that the dietary of No. 35 would have sufficed for his needs.

Nos. 36 and 37 represent the dietaries of Professor Ranke, of the University of Munich, in experiments upon himself, in which the total income and outgo were determined with a respiration apparatus. With very little physical exercise these quantities just sufficed him for the maintenance of his body without gain or loss.

Nos. 38 to 40 were reported by Forster. The Munich lawyer, No. 38, was in moderate circumstances, but able to have all the food that health demanded. The quantities here given are one-third of those consumed by a family of three adults. One-fourth of the carbohydrates of the food of the physician was taken in beer.

Nos. 34 to 40 were the dietaries of professional men in comfortable circumstances. Their food differed from that of the preceding and most of the succeeding dietaries in that it had much more of meat and other animal foods, and was hence more completely digestible; and that it had more variety, which made it more palatable.

No. 41. In contrast with these six dietaries of professional men, Nos. 35 to 40, which

were composed largely of animal food, may be cited that of an official of high rank in the German civil service, reported by Cramer. The official was 64 years of age, and had been a vegetarian for 11 years. He was in good health and possessed of a great deal of physical endurance. The character of the food in this dietary differs considerably from that in No. 44, as the official was not a so-called strict vegetarian, but used milk, eggs, and warm food. The food was weighed and its composition determined by analysis. Digestibility was also determined.

No. 42 was reported by Forster. This mechanic was connected with a laboratory, was in very comfortable circumstances, had considerable animal food, and did very light muscular work.

No. 43 is the dietary of a shoemaker in Rostock, observed by Hoch.

No. 44 is the dietary of an upholsterer, 28 years of age, in Munich. He was a strict vegetarian, and had lived for 3 years upon an exclusively vegetable diet, containing no warm food, and consisting of bread, fruit, and oil. The man was normally developed, appeared to be well fed, and weighed 57 kilograms (125 pounds). This dietary is reported by Voit, and the food was weighed and analyzed. The digestibility of the food was also determined.

No. 45 represents the average result of examinations by Voit of the food of 3 well-paid mechanics in Munich. It consisted of meat, bread, other vegetable food, and beer. The quantities and composition of the food were estimated.

No. 46 is the average of 2 dietaries of locksmiths, 7 of carpenters, and 3 of coopers in Bavaria, given in a royal Bavarian commission report.

Nos. 47 and 48 were also reported by Forster.

No. 49 is the average of 5 dietaries of Bavarian farm laborers reported by the same commission referred to in No. 46.

No. 50 is the average result of examinations by Steinheil of the food of miners near Ems, Prussia, at severe work. The food included meat, bread, potatoes, beans, and other vegetables in considerable variety, and butter. It is probable that actual weighings of the food were made; its composition was estimated presumably from Voit's compilations.

No. 51 is the average of 6 dietaries of Bavarian brewery laborers, reported by the Bavarian commission above mentioned. Their work is very severe, and they are noted for consuming large amounts of food, of which beer furnishes a considerable proportion of the carbohydrates.

The figures for the individual dietaries of which Nos. 46, 49, and 51 express the averages, are as follows: The protein in the mechanics' dietaries varies from 47 to 183 grams, and the energy from 1,690 to 5,285 calories. I have not the original data at hand, but the source would seem to vouch for their reliability. The range is very wide, but I am inclined to think not wider than might be found among people of similar occupation in ordinary communities.

Dietaries of workingmen in Bavaria.

	Nutrients.			
	Protein.	Fats.	Carbohy- drates.	Potential energy.
	Grams.	Grams.	Grams.	Calories.
Locksmith.....	109	41	407	2,495
Do.....	78	12	331	1,790
Carpenter.....	149	25	974	4,835
Do.....	163	30	1,058	5,285
Do.....	173	59	513	3,360
Do.....	183	52	761	4,355
Do.....	65	22	228	1,405
Do.....	99	52	585	3,290
Cooper.....	124	22	651	3,380
Do.....	47	7	350	1,690
Do.....	147	50	409	2,745
Average of 11 dietaries of mechanics.....	122	34	570	3,150

Dietaries of workingmen in Bavaria—Continued.

	Nutrients.			
	Protein.	Fats.	Carbohy- drates.	Potential energy.
	Grams.	Grams.	Grams.	Calories.
Farm laborer	131	61	609	3,600
Do	123	61	557	3,355
Do	189	63	683	4,160
Do	95	33	304	1,940
Do	147	59	559	3,445
Average of 5 dietaries of farm laborers.....	137	55	542	3,300
Brewery laborer	197	63	897	5,070
Do	122	34	674	3,580
Do	85	32	728	3,630
Do	116	61	566	3,365
Do	223	113	909	5,690
Average of 5 dietaries of brewery laborers.....	149	61	755	4,270

No. 52 is the dietary reported by Ranke of a large number of Italian brickmakers working near Munich during the summer. Some three hundred were in charge of a superintendent, who provided them with food which consisted of maize meal and cheese, with occasionally a small amount of brandy. The labor was decidedly severe. The amounts of food materials were based upon statistics furnished by the superintendent. The composition was estimated by Ranke, but his assumed composition of maize evidently does not represent the maize of this region. The amounts of nutrients given in the table are recalculated, using for the composition of maize the averages of analyses of maize grown in southern and southwestern Europe.¹

No. 53 is the dietary of machinists, etc., employed in the Krupp gun works at Essen, reported by Prausnitz. It has been for many years the endeavor of this firm to do all in its power to improve the food and quarters of its employees. The boarding houses (menage) were established in the interest of the unmarried workmen and those whose families lived at a distance, the purpose being to furnish them with suitable board and comfortable lodging. They were opened in 1856 with 200 members; this number gradually increased with the extension of the works, until at the time of the investigation in 1890 it had reached about 800. Since 1884 all unmarried workingmen, except those receiving high wages for special work and those living with their relatives, have been obliged to live in the company's boarding houses, a regulation which has been advantageous to both boarding houses and boarders. The price for dinner and supper together is 80 pfennigs (19 cents) per day. This does not include bread, but each man receives one-eight kilogram of coffee and one-fourth kilogram of butter per week. At dinner and supper the meat is served in individual portions; the men are allowed to take as much as they choose of all other dishes.

The average quantities of nutrients furnished in the dinner and supper are 115 grams protein, 81 grams fats, and 480 grams carbohydrates per day. In addition to this an allowance of 400 grams bread and 36 grams butter is made for the breakfast, which brings the total nutrients up to the amounts stated in the table. Prausnitz regards these figures to be the minimum estimate, as the daily amount of bread is placed very low, and milk, sugar, and beer are not included; this would fully balance all food wasted in preparation and at meals. The quantities of food materials are estimated on the basis of the bills of fare and their composition from König's averages.

No. 54. This represents the average of 6 dietaries examined by Höfler of farm laborers in the district of Tölz, in upper Bavaria. The dietaries are included in a very interesting description of the region and the people. The author says, in speaking of the peasants of the district and their very unusually ample nourishment:

¹ König, *Chem. d. mensch. Nahr. u. Genuss-Mittel*, third edition, I, 559.

“The influence of their food upon their bodily development is very noticeable. The people are tall, extremely strong, and sinewy; they are not fat, but their organic albuminoids (muscular as distinguished from fatty tissue) are well developed. * * * Really ‘fat’ men, that is to say, men with large deposits of fat in the body, are rare among the peasantry of this region. They have large and muscular frames and are among the best built men in the army enlistment rolls. * * * Aside from their severe work, a still further reason for the peculiarity of their food (large total amount and especially large quantities of fat) is found in the climate. * * * The low temperature and the constant wind make the large amounts of fat a necessity. * * * People who have to endure such ranges of temperature as prevail here, without especial protection by clothing, and not suffer in health, must be enabled to regulate the bodily warmth by large supplies of easily combustible fats and carbohydrates in the food.”

The food consists of bread, flour, potatoes, more or less garden vegetables, milk, cheese, grease, and butter. The protein, outside that of the bread and flour, comes mainly from milk, cheese, and curd, the fats from grease and butter which are consumed in large quantities, and the carbohydrates from wheat, barley, and potatoes. Sugar is little used because of its cost. The description does not state how the dietaries were estimated, but only gives the quantities of nutrients as stated beyond.

No. 55 is the average of 3 dietaries of lumbermen—1 from Tölz, as reported by Höfler, and 2 from other parts of upper Bavaria, as reported by Liebig. These are in size and amounts of fat and of energy entirely exceptional among the European dietaries of which I have been able to find record, and rank even with the larger, though they are far from approaching the largest, of the American dietaries given in the previous pages. Of the peasantry in the region where the 2 dietaries of lumbermen by Liebig were taken, Professor Ranke says:

“In contrast to the conditions prevalent elsewhere in Germany, the food of the country people in the Bavarian highlands and mountains is very ample, and although potatoes have not become the principal food material here, the food is chiefly vegetable. The famous peasant of the Bavarian mountain region, the genuine ‘Haberfeldtreiber,’ as he proudly calls himself, eats meat, in accordance with time-honored usage, only on the four great holidays of the year. He lives upon ‘Schmalzkost,’ that is to say, simple preparations of flour with which large quantities of fat are incorporated. To these he adds such materials as sauerkraut and dried apples or peas. The food of these powerful peasants is so generous as to explain their herculean development of muscle, their enviable vigor, and their consciousness of strength, which often leads to excess. * * * It is likewise a current observation by people in the Tegernsee Mountains that the lumbermen can do the more work the larger their appetites are.”

In comparing the dietaries of the Bavarian lumbermen, as reported by Liebig, with other European dietaries, I have sometimes, in my own mind, questioned whether the figures were entirely reliable as exponents of the eating habits of the class to which the men belonged. In matters of larger importance some of Liebig’s doctrines have been doubted, only to be confirmed by the results of later inquiry. In this minor though interesting matter of detail the teaching of the great master is substantiated by the figures which Höfler cites. It would certainly be a valuable contribution to the science of nutrition if a number of these peasant dietaries could be thoroughly studied.

The table herewith summarizes the data of the dietaries just mentioned.

Dietaries of men in Bavarian highlands.

Occupation and locality.	Nutrients.			Potential energy.
	Protein.	Fats.	Carbohy- drates.	
FARM LABORERS.				
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
Jachenau, Tölz, average of 3 estimates (Höfler).....	161	195	467	4,390
Gaissach, Tölz, average of 2 estimates (Höfler).....	166	201	734	5,560
Kirchbichl, Tölz, one measurement (Höfler).....	85	210	438	4,095
Average of 3 dietaries of farm laborers (Höfler).....	137	202	546	4,680
LUMBERMEN.				
Jachenau, Tölz (Höfler).....	144	358	606	6,405
Reichenhall Mountains (Liebig).....	112	309	691	6,165
Oberaudorfer Mountains (Liebig).....	135	208	876	6,080
Average of 3 dietaries of lumbermen.....	130	292	724	6,215

No. 56 to 59. Army rations, like other dietaries, are decidedly variable. The figures here are borrowed from very extensive compilations by Meinert. No. 56 is the average of 4 estimates by Voit, Artmann, Hildersheim, and Meinert, respectively. No. 57 is the average of 3 estimates by Artmann, Hildersheim, and Meinert. No. 58 is an extraordinary ration for soldiers in active service in the field.

German army management, from Frederick the Great to William and Moltke, has recognized the fundamental principle that soldiers to fight well must be well fed. No. 59 is therefore especially interesting as a ration ordered shortly after the outbreak of the Franco-German war, at the time of the terrible marching and fighting which brought the victories at Worth, Metz, and Sedan.

Austria.—No. 60 represents the average daily food consumption of 15 farm laborers in Central Transylvania as observed by Ohlmüller. The men were engaged in the severe work of harvesting from 4 o'clock in the morning until evening; their food consisted exclusively of maize meal and beans, and their only drink was water. The amounts of nutrients were estimated by Ohlmüller, who used the same composition for maize which Ranke used in No. 52 (Italian brickmakers). The nutrients are, therefore, recalculated, the same composition being assumed for maize as in No. 52.

Italian dietaries.—Nos. 61 and 62 are the dietaries of people of the poorer class in Naples, as observed by Manfredi and described above. No. 61 is the average of 5 dietaries of men, 2 shoemakers, a carpenter, a mason, and 1 without employment. No. 62 is the average of 3 dietaries of women (servants). Nos. 61 and 62 are described in detail on pages 173–177.

Nos. 63 to 65 are the average dietaries of a peasant 39 years of age, his wife, and son 14 years of age—a shoemaker—who lived in the neighborhood of Ferrara. They were studied by Albertoni and Novi. The family was in good health but very poor; their combined yearly earnings amounted to only \$97, of which \$81 was expended for food. Their food in winter was mainly maize and chestnut meal, macaroni, beans, fish, and lard. In summer the maize meal was in part replaced by bread. The food was accurately weighed and analyzed, as were also the urine and feces. Each of the 3 dietaries represents 2 periods of observation of 3 days each, one in March and the other in August.

No. 66 is the average of 4 Italian army rations, 2 for infantry and 2 for cavalry, in time of peace, as calculated by Moleschott.

France.—No. 67 was reported by Beaunis.

Children (Germany, Russia, and Switzerland).—Nos. 68 to 71 are averages of individual dietaries of children, with one or two exceptions in well-to-do private families. Of the 38 dietaries included in these averages 2 were observed by Forster, 3 by Uffelman, 10 by Hasse, and 23 by Camerer, all physicians. Forster's dietaries were those of 2 infants. One was in a laborer's family; it was 7 weeks old and was fed on a porridge made of milk, flour, and sugar. The other belonged to a well-to-do family; it was between 4 and 5 months old and was fed condensed milk. Both these children probably lived in Munich. Uffelman observed the dietaries of his own boys, from 2 to 15 years of age, in Rostock; only those of the three younger ones are included in these averages. Hasse made two series of studies of the dietaries of 4 girls, daughters of a well-to-do family in St. Petersburg; their ages ranged between 2 and 11 years. They were very well developed and their dietary consisted largely of animal food. The food was carefully weighed and its composition in parts determined by direct analysis and in part estimated from König's compilations. Hasse also observed the dietaries of two girls, aged 2 and 4 years, in a well-to-do family of Russian descent in Zurich, Switzerland. The food was essentially the same as that of the children in St. Petersburg and the method of the investigation the same. In all of Hasse's dietaries the period of observation ranged from 3 to 6 days.

Camerer made all told 7 series of dietaries of his own children, 4 girls and 1 boy, from 1878 to 1892. In 1878 the ages of the girls were 2, $3\frac{1}{2}$, 9, and 11 years, and that of the boy $5\frac{1}{2}$ years. In 1892 those of the girls were 15, 16, 22, and 24 years and that of the boy 18 years.

The general plan of these investigations consisted in observing the food of each child for 6 periods (in a few cases a less number), of 4 days each during each year. The 6 dietaries thus obtained were averaged together for the dietary of the child for the year, and these average (annual) dietaries are the ones included in the averages in the table.

Except in one of the 7 annual series weighings were made of the food actually eaten and its composition in part determined by analysis and in part estimated from König's compilations. In addition to these data the weights of the children were observed from day to day, the urine was collected and the urea determined and the feces collected, weighed, and analyzed. These studies were made in Riedlingen and Urach, in Würtemberg.

During the period between 1878 and 1892, 31 of these average annual dietaries were made, representing approximately 37 observations for each child or 186 for the five children. Only those dietaries of the children up to 14 years of age are here included. Of these there were 23 annual dietaries representing approximately (6×23) 138 observations of 4 days each. It should be added that the children were healthy and their growth was normal, although the girls who had attained the ages of 15 to 20 before the end of the study were somewhat smaller than the average.

These are by far the most extensive and valuable observations upon the food consumption of children which have been reported.

No. 68 is the average of the 2 dietaries reported by Forster, referred to above, and 1 by Camerer, that of a child not in his own family. This girl was 1 year and 2 months old and weighed 23 pounds. Her food was cows' milk, toast, gruel, beef tea, etc. The food was weighed and its composition in part determined by analysis and in part estimated from König's compilations. The average age of these 3 children was 8 months and their average weight 16 pounds.

No. 69 is the average of 14 dietaries, 9 of which are those of girls and 3 of boys from 2 to 6 years of age. Of the girls' dietaries 6 were reported by Hasse and 5 by Camerer. Two of the 3 boys were Uffelman's and the other Camerer's. The average age of these 14 children was 3 years and 10 months and their average weight 33 pounds.

No. 70 is the average of 8 dietaries, 6 of girls and 2 of boys from 6 to 10 years of age. One of the girls' dietaries was reported by Hasse. All the other dietaries are

those of Camerer's children. The average age of the 8 children was 8 years and 5 months and their average weight 53 pounds.

No. 71 is the average of 13 dietaries, 10 of girls and 3 of boys between the ages of 10 and 14. Eight of the girls' and 2 of the boys' dietaries were observed by Camerer, those of the other two girls by Hasse, and that of the boy by Uffelman. The average age of the 13 children was 11 years and 8 months and their average weight 70 pounds.

No. 72 is the dietary of children 6 to 15 years old, inmates of an orphan asylum in Munich reported by Voit, who pronounced the food satisfactory both as regards quality and quantity. The food was weighed as prepared for cooking, but no mention is made of actual analyses.

No. 73 is a dietary studied at a home for children in Gehlsdorf, near Rostock, containing 38 boys between 8 and 15 years of age. They were healthy and normally developed, and occupied in study and light work. The study was made by Schröder. The food was weighed as prepared for cooking and its composition was estimated. The rules of the institution did not permit waste of food at the table.

No. 74 is the dietary of girls from 14 to 19 years of age (average, 15½ years) in the Krupp training school for girls. This school represents one phase of the effort which has been made by the Messrs. Krupp to elevate the condition of their employees. The city of Essen, which has nearly 70,000 inhabitants, depends mainly upon the Krupp cast steel works, which employ some 10,000 workmen in the shops and 8,000 outside. While this establishment is of supreme interest to the mechanical engineer, the efforts of the Messrs. Krupp to promote the welfare of their employees are scarcely less so to the student of sociology.

The girls' training school has for its object not only the general education but instruction in those things which pertain to the care of the household and the duties of the wife and mother. The course in these latter branches lasts for 3 months, and includes purchasing of food, cooking, preserving and care of provisions, management of the kitchen garden, washing, ironing, mangling, knitting, darning, and all kinds of housework. In instruction in food economy the pupils are taught what quantities of food materials are required for a given number of persons and how much should be prepared for each meal. Each pupil is expected to provide for 10 others for a number of days. She must weigh out the necessary food materials and prepare and cook them. She must keep an exact account of what is used for each meal and the cost and quantities of the several materials employed. At the end of the course each girl takes her own account book, which makes a very valuable guide for her later in life, in that it tells her how a nutritious and at the same time varied diet may be furnished at a comparatively small expenditure. This dietary study was made in connection with No. 53, by Prausnitz. The quantities of food materials were taken from the girls' account books mentioned. The composition was estimated from König's compilations.

Japanese dietaries.—According to Mori 3 general classes of dietaries are common among the Japanese, namely, (1) that of the rural population of the interior. This is almost exclusively vegetable; fish is eaten but once or twice a month and meat but once or twice a year; (2) that of the population of the coast, who eat fish in considerable quantities, and (3) that of the city population and of well-to-do families, who eat both meat and fish to a considerable extent.

Rice is the principal article of vegetable food, but, in addition to this, barley, wheat, various kinds of millet, and buckwheat are eaten in considerable quantities. Tubers and roots, such as turnips and radishes, are staple articles of food, and pumpkins, cucumbers, etc., are much used. The legumes are little eaten in their natural state, but form the basis of a number of prepared foods and relishes, such as miso, tofu, and shoyu, all of which are made from the soja bean. The miso is prepared from cooked beans, which are rubbed to a thick paste and fermented with the ferment used in the preparation of the rice wine. Tofu, or bean cheese, is essentially the

legumin of the soja bean, which is first extracted with water and then precipitated by the addition of the mother liquor (magnesium chlorid), obtained from the evaporation of sea water in the manufacture of salt. The cheese is eaten fresh. The shoyu sauce is prepared from a mixture of cooked and pulverized soja beans, roasted and pulverized wheat, wheat flour, salt, and water. The mixture is fermented with the above-mentioned rice ferment for $1\frac{1}{2}$ to 5 years in casks. This sauce is used very largely by all classes.

Nos. 75 and 76 are dietaries of prisoners in Tokyo, observed by Eijkman. The food was exclusively vegetable, and consisted mainly of a mixture of one part of rice and one and one-half parts of barley cooked together. All of Eijkman's dietaries, Nos. 75, 76, and 80, were published in Japanese. Kellner and Mori and Nakahena in referring to them state that the food was in all cases weighed and its moisture content determined.

No. 77 is that of the employees in a large retail store in Tokyo, reported by Tawara. The period of observation covered only 3 days, but during this time no animal food was eaten; the food was essentially rice and salted radish. Tawara's dietaries, Nos. 77, 81, and 82, are also published in Japanese, but are cited by the writers above referred to, who state that the food was weighed and its composition estimated upon the basis of numerous analyses of Japanese food materials by Tawara and others.

No. 78 is the dietary of Mori, an assistant at the University of Tokyo. It was observed by himself, and he regards it as representative of the food of people in well-to-do circumstances and students in the higher institutions. It is materially modified by European influences (more meat and more protein), but on account of its expense has gained little footing among the majority of the people. The food was beef, rice, potatoes and other vegetables, and milk. The test was continued for 6 consecutive days, during the last 3 of which the food materials and also the urine and feces were analyzed. The amounts given are, however, those actually eaten.

No. 79 gives the average of the dietaries of two students in the University of Kyoto, as observed by Scheube. Meat and fish were eaten daily, and eggs, bean cheese (tofu), and green vegetables were also used. Each test was continued for 5 days. The food was weighed and its composition estimated.

No. 80 is the dietary of a military school in Tokyo, reported by Eijkman. The observations cover a period of several nonconsecutive days. Meat was served daily.

No. 81 is that of the inmates of a Government school in Tokyo, from 17 to 25 (average, 20) years of age. The cost of the food was \$4 per month per pupil. Meat was served once a day, and fish was eaten in considerable quantities. The period of observation covered 10 consecutive days.

No. 82 is the dietary of the pupils in a private school, also in Tokyo. Their ages ranged from 11 to 21 years. Meat was served only twice a week in this school, but fish was eaten regularly. The price of the food was about \$2.25 per month per pupil. Their food consumption was observed during one week. Nos. 81 and 82 are reported by Tawara. In the opinion of Kellner and Mori the quantities of food served to these pupils, of whom a considerable number were children, were somewhat excessive, and doubtless there were uneaten residues, especially of rice, which were not taken into account in estimating the amounts of nutrients. This would appear to be the case especially in No. 82.

Java.—No. 83. In connection with the study of the food of some of the interesting people from the less-known countries at the World's Fair, made under the auspices of the World's Columbian Commission,¹ an opportunity was furnished to observe with exactness the food consumption of several inmates of the Java village.

One of the houses was set apart for the purpose, and 2 families, including 2 women

¹A report of these investigations, which were conducted under the direction of the author, will, it is expected, appear with other reports of the World's Fair.

and 3 men, were assigned to live in it for a period of 10 days. They were enjoined to eat nothing except what was served in the house, and the cooks were charged to provide the fullest opportunity for collecting the data desired.

The men were engaged to a certain extent in the light occupations incident to the care of the village and in sewing. The women seemed to have no special occupation outside of the very small amount involved in the care of the house.

The food consisted mainly of rice and lean beef, the former furnishing nearly seven-tenths and the two together nearly five-sixths of the total actual nutrients. In addition, chicken, fish, eggs, bread, green vegetables, and fruits were eaten in small quantities. So far as could be ascertained this did not differ very greatly from the home diet.

The investigations covered a period of 10 days during September, 1893. The food was carefully weighed as prepared for the table, and its composition in part determined by analysis and in part estimated.

DIETARIES IN THE UNITED STATES AND CANADA.

Massachusetts and Canada.—Nos. 84 to 115 were described on pages 145–156, above.

Connecticut.—In 1886 and later several dietaries of students, laborers, and one of a well-to-do private family in Middletown, were examined in connection with the study of Nos. 84 to 115. Nos. 117, 121, 122, 124, and 126 are selected from the group. The method employed is indicated in the text beyond. In general it was the same as that used in the Massachusetts dietaries, except that account was taken of the quantities of food rejected in the kitchen and table waste, and the amounts actually eaten were computed by subtracting these from the food purchased. In 1890 and later these investigations were renewed at Middletown in cooperation with the United States Department of Labor and as a part of the work of the Storrs Station. Nos. 116, 118 to 120, 123, 125, and 127 to 134 belong to the group thus studied. The method employed has been essentially that described on pages 200–204.

Dietaries of well-to-do private families in Middletown and Storrs.

No. 116 is the dietary of the family of a chemist in Middletown. During the month of April, 1891, the food actually eaten in the family of a chemist in Middletown was carefully weighed, and while no analysis was made of the food or of the table waste, it is believed that the figures given below are quite reliable. The family consisted of 1 man, a chemist, 34 years old and weighing 230 pounds, his wife, and a maidservant, who were at home during the entire month; also 1 man, a chemist, 27 years old and weighing 175 pounds, and an elderly woman were at the table about one-half of this period. The food materials used were mostly of such a nature that their composition is fairly well known from the averages of other analyses. The waste was reduced to a minimum, and it is probably fair to assume that no very considerable error was introduced by neglecting it. As both of the station chemists lived in the family and the wife of one of them was very much interested in the experiment, a very careful account of the weights of food used was kept. For the most part the food was weighed just before using, on a scale sensitive to 1 gram, with a charge of 10 kilograms.

No. 117, dietary of a professor's family in Middletown. The weighings and estimates for this dietary were made by Mr. Rockwood, assistant in the chemical laboratory of Wesleyan University. On the 1st day of January accurate account was taken of all the food materials in the house. The quantities of food brought to the house during January, February, and March were estimated from the grocer's, butcher's, and other bills. During the same period all the food left unconsumed, i. e., the kitchen and table refuse, was carefully kept, weighed, and its composition estimated. On the 1st day of April the food materials remaining in the house were weighed. In estimating the quantities of nutrients the method employed for those of the Massachusetts and Canadian dietaries was used.

The smallness of the waste is explained by the fact that the mistress of the house was a particularly careful housekeeper.

Nos. 118 and 119 are the dietaries of a professor at the Storrs Agricultural College. In the dietary made in the winter of 1893 the family consisted of the man, 32 years of age, his wife, and a maidservant; in that of the summer of 1893 the family was the same, except that the servant was absent and a child 1 year old included.

No. 120 is the dietary of the family of a retired jeweler. The family consisted of the father, 70 years of age, at very light work; his wife; their son, a chemist, 23 years old, with moderate exercise, and their daughter. The study was made during the month of September, 1891.

Dietaries of college and professional students in Middletown.

Nos. 121 to 123, three dietaries of a college students' club. A large number of the students in Wesleyan University board in clubs. The club, which may have any number of members up to 30, chooses one of its number as steward, and arranges with a matron to cook and serve the food which he purchases. Many of the members have to pay their way through college; the majority are obliged and the rest are content to have the cost of their board made low, even at the sacrifice of delicacies. While their diet is substantial and wholesome, they regard it as plain and economical. They are mostly from the Eastern States, and coming from the class of families whose sons go to college, it seems fair to assume that their habits of eating formed at home would not differ materially from those of the more intelligent classes of people in that part of the country. While the habits of many are sedentary rather than active, they nevertheless take considerable muscular exercise. In this respect they are very much like the students of other Eastern colleges. They are given to athletic sports in pleasant weather. Out of 250, sometimes 70 or more may be seen at once on the campus playing tennis and baseball. They could hardly be credited with as much muscular exercise on the average as laboring men doing moderate work, and they would therefore, without doubt, require somewhat less of protein as well as of the other nutrients in their food. Their requirements doubtless approach closely to those of the man with moderate exercise.

From the accounts of one of these clubs for a period of 3 months in 1886, the amounts of the several kinds of food materials purchased and the quantities of nutrients were computed. The results are given in No. 121 of the table.

The figures thus obtained represent what the students paid for, rather than the amounts actually consumed. The steward and some of the members of the club were of the opinion, however, that the amount of waste—that is to say, the material thrown away—was very small. It costs too much. But on investigating the matter more closely it appeared that a portion of the material served was left upon the plates and found its way into the garbage barrel or was given away. The rejected food was, therefore, collected during 1 week and weighed. Its composition was estimated and the amount of waste calculated.

The following term an examination of the dietary of the same club was made by Mr. Videon. Another steward was then in charge. He had learned of the excessive amounts of food in the former dietary, and planned to reduce the quantities. This was done largely by diminishing the meats. He states that he did not apprise the club of the change, and that it was not noticed. As he put it, "The boys had all they wanted, and were just as well pleased as if they had had more." The quantities of nutrients in both dietaries were estimated by the method already described. The waste in the second dietary was estimated with some care. In this, as in the first, it is assumed that the difference between the food purchased and the waste represents the actual consumption.

In the spring of 1893 the dietary was examined for a third time (No. 123). The observations were much more accurate, that is to say actual weighings and analyses were made of the food consumed.

No. 124 is the dietary of a second students' club. The members of the club were in moderate circumstances and felt the necessity of economizing, but at the same time intended to have an abundance of wholesome food. The observations were made by one of the members who was an advanced student in the chemical laboratory and much interested in these studies. The food materials were actually weighed and also the waste. The attention of the club had been called to the waste in the dietaries of the other clubs. In all probability this is the explanation of the smallness of the waste here.

No. 125 is the dietary of the members of a boarding club in a divinity school. The details are not yet published. The method was essentially that described beyond on pages 201-213.

No. 126, dietary of a college football team. This dietary was examined at a time when the team was in active training and boarding in a club by themselves. The observations were made at the same time and by the same person (Mr. C. S. Videon) as those of Nos. 122 and 124. Their exercise was vigorous and at times severe, but the examination was made near the close of the football season, when, in the judgment of members of the club, they were eating rather less heartily than they had done earlier in the season.

Mechanics, etc., in Middletown.—No. 127 is the dietary of a boarding house. The dietary commenced with supper, October 20, 1890, and continued until after dinner of November 19, a period of 30 days. During most of the time the family consisted of 13 men and 7 women. It very rarely happened that all of the family took all three meals at the house any given day. There were occasional visitors, and in this way once or twice the total number of meals taken per day was larger than the family alone would have required. The sex, approximate age and occupation of each member of the family, as it was constituted most of the time, were as follows:

Men:

Machinists, 30 to 40 years of age	4
Machinist, about 35, after October 25.....	1
Harness maker, about 70.....	1
Hired men about the stable, one old, the other middle aged.....	2
Proprietor of the house, about 70	1
Manufacturers, one about 60, the other about 30	2
Chemist, about 27	1
Reporter for newspaper, about 20, after October 27	1
Total	13

Women:

Housekeeper, about 30.....	1
Cook, about 45.....	1
Table girl, about 20.....	1
Doing no manual labor, about 30, 55, 55, and 70.....	4
Young lady at house 4 days, doing no labor.....	1
Total	8

Of the 13 men, 3 were counted as "heartly eaters," and 6 more as having decidedly good appetites.

No. 128 is the dietary of the family of a machinist, consisting of the father, born in Germany, 50 years of age, his wife, and 3 daughters, from 14 to 20 years of age. The period of observation was 30 days during November and December, 1891.

No. 129 is that of the family of a blacksmith and consisted of the father, a Canadian, about 40 years old, his wife, and 2 boys, 8 and 10 years of age. The study was made at the same time as No. 128.

Nos. 130 and 131 are 2 dietaries of the family of a stone mason. The father, born in Sweden, was about 28 years of age; the mother was also a Swede and had been in

the United States only about 3 years; the other member of the family was a child 7 months old. The first study was made in November and December, 1892, and continued 28 days; the father was at work during 3 of the 4 weeks. The second study was made in April, 1893, under approximately the same conditions as the former one.

No. 132 is the dietary of the family of a carpenter. The family was of American birth and consisted of the father, who was about 25 years of age, the mother, and a boy 2 years of age. The study was made in November and December, 1892, and covered a period of 28 days.

Nos. 133 and 134 are 2 dietaries of another carpenter's family, also American, and consisting of the father, about 35 years, his wife, and a boy 11 years of age. The first dietary covered a period of 28 days in November and December, 1892, and the second a period of the same length in April and May, 1893.

Pennsylvania.—No. 135 gives the average minimum and maximum of 25 families in the poorest part of Philadelphia. With a single exception all of these families¹ were either foreign or of foreign descent.

Illinois.—No. 136 gives the average minimum and maximum of 26 families in the poorest part of Chicago.

Nos. 135 and 136 were made in 1892-93 by Miss Amelia Shapleigh, Dutton Fellow, of the College Settlements Association. Complete and exact accounts of food bought and eaten by 55 families in Philadelphia and Chicago, representing as many nationalities as possible and selected at random from the neighborhood of the settlement, were collected. The estimates ("amounts of food actually bought and put on the table") were made "after close questioning, observation, and in case of food not bought by the pound, careful weighing." Ten per cent of the total was deducted for rejected and undigested residues. No analyses of food materials were made and the basis upon which the amounts of nutrients was estimated is not stated.

United States Army and Navy rations.—It is difficult to compute exactly the food consumption by soldiers in the United States Army, because the men have more or less of opportunity to select or add to their food by commuting purchase or otherwise, so that the food actually used varies more or less from the regulation rations. The best data for calculations I have found are those contained in Circular No. 8 of the Surgeon-General's Office, United States Army. From these Mr. Woods has computed the nutrients and energy as stated in Nos. 137 and 138.

SUGGESTIONS REGARDING STUDIES OF DIETARIES.

The following statements are gathered from the experience of the writer and his associates, supplemented by their reading of the reports of the work of others.

The object of a dietary study is to determine the kinds and amounts of food materials and of nutriments consumed by one or more persons during a given period and under known and definitely stated conditions. The first essential is accuracy in the collecting of the original data. If these are indefinite, unreliable, or incomplete, the defects can not be compensated by the most accurate and painstaking chemical analysis, by elaborate treatment of the results, or even by a large number of observations. This accuracy is needed even in the smallest details; no part of the study of a dietary calls for more thought and care than the collection of the statistics regarding the food materials consumed, the people who consume them, and the proportions actually

¹ 1 American, 3 Irish, 6 German, 6 Jewish, 3 Italian, and 6 Negro.

eaten and not eaten. When these preliminary data have been properly collected, and the specimens have been secured for analysis, the work up to the writing of the results is largely a matter of routine which can be carried out in any well-ordered laboratory which is equipped for this kind of investigation. The reporting and especially the interpreting of the results requires not only an understanding of chemistry and physiology, but also an appreciation of some of the fundamental facts and principles of economics and sociology.

The philosophical study of food consumption requires the skill and the training of the chemist, the physiologist, the statistician, and the sociologist.

I. *Qualifications of the observer.*—For these reasons the person who collects the statistics should have a thorough scientific training and a clear idea of the questions involved and the importance of the task. Besides the technical knowledge, a goodly amount of tact is indispensable and the best success requires a certain sympathy with the people among whom the work is done, especially when they are in moderate circumstances or belong to the poorer classes. Food and household expenses are delicate subjects. A housewife or mistress of a boarding house may object to having her kitchen and account book subjected to critical examination unless it is done with tact. Perfect frankness and an explicit statement of the nature of the statistics, at the beginning of the study, is the safest rule. Often the offer of a small sum of money in compensation for the trouble caused by the inquiry will materially help the observer. The questions, often very direct, which the observer is obliged to ask, and the close watch which he must keep over even the smallest details of food purchased and wasted during the course of the investigation, are liable to place him in situations where deference is needed, for the good will and interest of the family must be kept at any cost, inasmuch as the observer is entirely dependent upon the subjects of his investigation for so much of his statistical information. Whether the observer had better be a man or a woman depends upon the individual and the circumstances of the case.

II. *Selection of persons for study.*—Whether the dietary to be studied is that of an individual (man, woman, or child), of a family, or of any other group of persons, as a boarding house or club of people of like class and occupation, the person or persons should be typical of a class, and normal in respect to health, development, and age.

(a) *Health.*—Families or groups containing invalids are not appropriate for the study of normal dietaries; neither should persons whose occupations or general habits exert an abnormal influence upon their dietary habits be selected, except in cases where special studies of the effect of such conditions are to be made.

(b) *Development.*—Greatly oversized or undersized persons should not be selected or included, and when children (either in families or

individual experiments) are included or selected, height and weight as well as age should be carefully noted.

(c) *Age*.—Families or groups containing extremely old persons are hardly desirable. Studies of the food consumption of children or of aged people are best made with such persons by themselves.

Other conditions being the same, the greater the number of persons included in a dietary study the more valuable are the results as representing a class. There is, however, a limit in this direction which is set by the amount of labor which such a study involves. Accuracy and thoroughness must never be sacrificed, and the dietary of 1 person thoroughly studied is worth much more than that of a group of 20 or 30 studied indifferently. The number of imperfect studies is already considerable, and although they are valuable for the preliminary reconnaissance, the demand now is for a more accurate form of inquiry, which shall bring to light exact and not merely approximate facts. An experienced investigator with good laboratory facilities and plenty of assistance for the analyses, and especially for the preparation of samples of food materials and wasted food, may undertake the study of the dietary of a club of 25 or 30 persons, but it would be hardly advisable to undertake so large a study, even with all needed help, until considerable experience had been gained in the study of dietaries of individuals and families. The errors of my own early experience are the reason for the emphasis of this statement.

III. *Length of period of observation*.—One of the most serious criticisms to be made of a number of otherwise admirable dietary studies is that the period of observation has been too short. The demands of the organism for food may vary considerably from day to day. Changes in occupation, differences in the temperature and in the state of the weather in general, and minor ailments resulting from fatigue, exposure, or mental condition have a considerable effect upon the appetite; so that differences from one day to another may amount to a considerable portion of the total quantity of food consumed. For example, in a recent Italian dietary (No. 63 of Table 37) the period of observation covers 3 consecutive days, during 2 of which the subject was at work, while the third was a day of rest. On one of the working days he ate one-fourth more than on the other, and one-third more than upon the day of rest. This is by no means an extreme or exceptional case. For this reason studies of dietaries, either of individuals or families, covering a period of less than one or two weeks are not to be recommended unless they are to be frequently repeated, as was done by Camerer (see page 192). One month is a much more desirable length. Even for larger groups the time of observation should not be much less, inasmuch as, other conditions being the same, the longer the period of observation the more reliable the result.

IV. *Food*—1. *Collection and measurement of food materials*.—At the beginning of the study of a dietary a careful inventory should be taken

of food materials¹ in stock in the kitchen, pantry, and cellar. The materials should in all cases be weighed rather than measured, and this applies not only to such materials as meats and flour, but also to such as milk, molasses, potatoes, beans, and other vegetables. Like accurate weighing should be made of all food materials purchased during the period of observation. Each should be carefully weighed when received; it is not safe to trust to purchase weights; in the case of meats, for instance, the cut may be trimmed at the market after weighing. At the end a second inventory should be made with the same precautions as observed at the beginning. The sum total of the food materials at the first inventory and of those received during the study, less the amount indicated by the final inventory, shows how much has been used during the period of observation.

2. *Description of food materials.*—The description of the various food materials, including that of each portion, e. g., each cut of each kind of meat, should be detailed, whether a sample is taken for analysis or not. The economic value would be increased by statements of price and quality. This is particularly to be observed in case of the meats; not only the kind, but the exact cut should be mentioned.

3. *Sampling for analyses.*—Samples of all food materials which form any considerable part of the dietary should be analyzed. This list usually includes all the meats, samples of which should be taken with each individual purchase, the lard, milk, butter, flour, oatmeal, and other vegetable foods, including canned vegetables and sugar.

The procuring of representative samples of meats is less simple than one without experience would suppose. To obtain fairly representative samples of steaks, chops, roasts, or ham is comparatively easy, as alternate or adjacent slices are readily procured at the time of purchase, but in the case of the miscellaneous cuts which form such a large proportion of the meat used in many kitchens, the problem of getting fair samples is often very perplexing. The matter is, however, one of foremost importance, and the only safe rule is to obtain samples at each and every purchase. To illustrate by a concrete example: In New England the custom of serving veal and mutton stews is very common. The meat selected for this purpose consists usually of the odds and ends of veal or mutton which happen to be in the market at the time, an assortment which it is impossible to duplicate. The best expedient we have found is to have these miscellaneous pieces cut into smaller ones—as small as possible without injuring the appearance of the meat—and

¹ In the studies of dietaries certain articles of food and drink are not, as a rule, included in the category of food materials. They are such as tea, coffee, salt, spices and condiments in general, including beef extract. Beverages containing nutritive material, e. g., beer, should be taken into account with food. Alcohol when consumed in small quantities, should be included (1 gram alcohol is approximately equivalent to 1.7 grams carbohydrates in fuel value); if alcohol is taken in large quantities the subject would not be fitted for observations upon normal nutrition.

to select for analysis pieces representative of the whole lot as regards proportion of meat and bone and lean and fat.

The practice of buying meat from the butcher's cart, instead of at the market, is a common one in many localities and makes the getting of samples for analysis very difficult, unless previous arrangements are made by which the piece of meat purchased shall be large enough for the use of the family and for the sample to be analyzed. The observer should always be at the market or meat wagon when purchases are made if this is possible, and must in any event attend to the taking of the sample for analysis whether at the market or in the kitchen; the market is generally the most convenient place for taking the sample.

Samples of flesh of large fish, such as halibut, salmon, etc., may be taken in the same manner as samples of meats, but with smaller fish which are sold by the piece and likewise with shellfish and also poultry and eggs, one or more samples similar in size and general appearance to those purchased for food should be selected for analysis.

Milk should be thoroughly mixed before sampling, and butter and cheese should be sampled as recommended by the Association of Official Agricultural Chemists.¹

Lard may be sampled in the same way as butter.

The obtaining of representative samples of vegetable foods, such as flour, cereals, and vegetables, is comparatively easy, as is also the case with canned foods, whether animal or vegetable. Too much care, however, can not be taken to make sure that the samples for analysis shall be representative, as otherwise the accuracy of results will be greatly diminished.

4. *Analyses*.—Meats vary so much in proportion of refuse and edible portion and in the composition of the edible portion that it is necessary to analyze every piece if the work is to be exact. Indeed, we have felt compelled in late dietary studies to chop all the meat and take a small sample of each lot for analysis. This, of course, interferes with the cooking, but it makes more accurate sampling possible. With fish and poultry the necessity of repeated analysis is perhaps not so great. Milk should be analyzed very frequently, but the number of analyses may be considerably lessened by combining several samples taken upon different days. Butter should be analyzed at each purchase. Granulated sugar is usually free from moisture and mineral matter, but the moisture content of soft sugars and of molasses should be determined.

5. *Waste*.—From the economic standpoint the waste of food in American households is a serious matter, and it is desirable that exact statistics should be obtained and published. In the dietaries which we have studied the quantities of actual nutrients which have found their way to the garbage barrel have frequently amounted to a tenth, and in one

¹ See proceedings of the annual conventions of this association. U. S. Dept. Agr., Div. Chem.

case rose to a sixth of the whole food purchased. The real waste was worse than these figures imply, because the rejected material came very largely from animal food in which the nutrients are more costly than in the vegetable food materials. In the reports of dietary studies by the writer and his associates the term "waste" has been applied to all of the so-called "edible portion" of food which may for any reason be rejected. It includes all uneaten residues of the cooked food, e. g., meats, vegetables, bread, cake, and pastry, except, of course, the bone and other parts of meats and fish which would be classed as "refuse" in food analysis. It also includes all portions of food materials which are rejected before cooking, except those which belong to the refuse. Such materials as the parings of potatoes and turnips are reckoned as belonging to refuse, and are not included in the waste; they are, however, weighed, and their weights compared with the whole weight of the food material in order to determine the proportion of refuse.

Collection of waste.—The collecting of the waste is always difficult, as there are so many avenues through which it may be lost, and unless the observer can personally superintend its collection at each meal, the most explicit directions for the care of the garbage barrel and soap-grease bucket are necessary. When once collected the waste food materials should be carefully looked over, and bones (from which all adhering meat must be removed) and all hard substances, such as fruit pits, etc., which may have been accidentally included, should be removed. The waste is then to be dried for analysis.

Sampling.—The waste when thus partially dried is exposed to the air of the room for 28 to 48 hours and then weighed, chopped into pieces about the size of a pea, and carefully sampled. This sample, which should weigh about a kilogram, is very finely chopped, and a final sample of the customary size taken for the actual analysis. When the amount of waste is very large samples should be taken comparatively often, but in the case of an ordinary family the waste food for a period of 4 weeks will not present any special difficulty in obtaining a representative sample. When several samples are taken they may, of course, be combined, if care be taken that the amount of each particular sample which enters into the composite one shall be proportional to the quantity of waste which it represents.

Analysis.—The waste usually contains little crude fiber and only determinations of moisture, nitrogen, ether extract, and mineral matters are necessary.

6. *Digestibility.*—The ideal dietary study would include a digestion experiment. That is to say, the solid excreta from the food would be collected, weighed, and analyzed. This has been done in some of the recent work in Italy, Germany, and Japan.¹ Work in this direction in the United States is much to be desired.

¹ See detailed account of Nos. 44, 61 to 65, and 78, and special description of studies by Manfredi, pp. 173, 188, 191, 194.

V. *Data as to persons, length of period of observation, and climate.*—The most important of these data are the sex, age, weight, and occupation of the persons and the length of time during which their food consumption is observed.

1. *Sex.*—The number of persons of each sex must be noted. The estimation of comparative food consumption of men, women, and children and the number of men to which the number of women and children would correspond is explained beyond.

2. *Age.*—The exact age of each person, and especially of each child, should be recorded.

3. *Weight.*—The weight of each individual, or the average of all, should be noted—this especially to be borne in mind with children, statements of whose development, both weight and height, are also desirable.

4. *Occupation.*—The occupation of each person should be stated in detail. The relation between food consumption and the kind and amount of work done is as yet too little understood, and data bearing upon it much to be desired. It would obviously be misleading to compare the dietaries of professional men with those of men at muscular labor, and those of men at muscular work of different degrees of severity, without taking the nature of the labor into account. Of course these estimates of the severity of different kinds of labor can not be definite, but they should be described as accurately as possible.

5. *Time of observation.*—The exact times during which the food consumption of each person is observed must be carefully noted. This is most easily done by keeping an exact account of the number of meals eaten by each person during the period of observation. The number may be expressed in terms of days by dividing the total number of meals by the number of meals per day. This procedure is to be recommended, because members of the family or other groups are apt to be absent more or less from meals, and other persons are often present at meals.

6. *Climate, season, temperature.*—If the people spend their time in well-warmed houses, differences of climate and season may perhaps have little influence upon food consumption. Otherwise these factors may be most important. But little is certainly known as to their actual effect, and data are most desirable.

7. *Supplementary statistical and sociological data.*—In addition to the statistical data above referred to, certain other information is needed to give the results their full meaning. Nationality, home life, environment, health, income, and expenditures are among the data to be especially considered.

VI. *Calculation of results.*—The statistics of food consumption in dietaries are usually reduced to terms of nutrients consumed per man per day. Data as to total amounts of food materials of different kinds and of food wasted and the composition of each are obtained in the manner mentioned above. From these we may calculate the total amounts

of protein, fats, and carbohydrates. Dividing these quantities by the total number of days' food for 1 person gives the quantities *per person* per day. This, however, is not sufficiently accurate, for it is necessary to distinguish between persons of different classes. It would be obviously unfair to compare the amounts of nutrients consumed by a child 5 years of age with those consumed by an adult man. It is therefore desirable to express the food consumption of men, women, and children in equivalents of per man per day. To do this we must find the ratio which the food consumption of children of various ages and of women bears to that of the man.

The ratios used in the dietary studies by the writer and his associates are the same as were explained on page 148. It may prove desirable to change them later. I hope to revert to this in a future discussion of standards for dietaries. Dietary habits are numerous and complex, and a dietary studied without taking these elements into account is thereby deprived of its real significance.

CLASSES OF PEOPLE AND LOCALITIES FOR DIETARY STUDIES.

The studies which have so far been made are limited in locality to several towns and cities in Massachusetts and Connecticut, and to Philadelphia and Chicago. In New England these studies include dietaries of professional men and students, factory operatives, mechanics, such as blacksmiths, carpenters, masons, and machinists, and also various classes of less skilled laborers, such as brickmakers, etc. They are very likely, so far as they go, typical of the town population of the New England States. In Philadelphia and Chicago only the food consumption of families of the poorer classes of society, mostly foreigners, has been studied.

It now seems desirable that these studies should be extended in two ways. They should include a number of classes of people and cover a larger territory. They can be advantageously carried on with the aid of colleges and experiment stations, although other organizations, as labor bureaus and benevolent societies, might most advantageously cooperate.

Among the classes that need to be studied are: First, people in professional and business life; those whose labor is intellectual rather than muscular. These would include the families of business and professional men, and likewise students. Second, farmers and their families in the country districts. Third, mechanics of different classes, and with muscular work of different degrees of severity, as carpenters, masons, blacksmiths, etc. Fourth, factory operatives. Fifth, ordinary laborers of various classes. Sixth, people of the poorer classes in the large cities. Seventh, inmates of hospitals and prisons. Eighth, children of different ages.

CHAPTER X.

STANDARDS FOR DIETARIES.

Various standards have been proposed by physiologists and chemists for daily dietaries for persons of different age, sex, and occupation, and in different conditions of life. They are usually estimated in terms of the three classes of nutritive ingredients, protein (or albuminoids), fats, and carbohydrates.

Our best information regarding dietary standards has come from Germany where studies have been made by numerous investigators, such as Liebig and especially Voit and his followers of the Munich school of physiologists. Voit's standards are the ones most commonly followed in estimates of dietaries. Outside of Germany the names of Playfair in England, Payen in France, and Moleschott in Italy, deserve especial mention as contributors to the knowledge of the subject. It is a noteworthy fact, however, that very little attention appears to have been paid in either the United States or England to the results of the latest and best research in this direction. Even the text-books on chemistry and physiology in the English language which are looked upon as most authoritative are apt, when they treat of the matter, to do so most superficially.¹

Unfortunately, in the treatment of this subject there is much confusion as to the real significance of the term dietary standard and the basis upon which the standards may be estimated. The same confusion obtains in still greater degree in the discussions of standards of rations for domestic animals.

METHODS OF ESTIMATING DIETARY STANDARDS.

A standard for a ration or a dietary may be based upon either:

(1) The observed facts of consumption. Thus the standards of Playfair, Moleschott, and Voit for a laboring man at moderate work are based mainly upon the quantities actually consumed by persons whose food consumption they had learned from their own or other observations.

¹The subject is well handled in a number of German works including the following, in which references to the original investigations may be found:

Voit. *Physiologie des allgemeinen Stoffwechsels und der Ernährung*, Vol. V, of Hermann's *Handbuch der Physiologie*, 1881.

Foster. *Ernährung und Nahrungsmittel* in Vol. I, of Pettenkofer and Ziemssen's *Handbuch der Hygiene*, 1882.

König. *Chemie der menschlichen Nahrungs- und Genussmittel*, 3d edition, Vol. I, 1891.

Hammersten. *Physiologische Chemie*, 1891.

(2) The actual need and available or most economical supply. Standards estimated on this basis would take into account not only the actual demands of the body for nourishment, but also the kinds of food that are to be had and the pecuniary cost of the nutrients in different food materials.

(3) The physiological demand. By this is meant the quantities of nutrients which are most appropriate for the particular individual or class. The basis here would be found in the actual facts of normal metabolism. The data of this sort now at hand are too few to make estimates reliable.

Standards estimated upon the first basis would correspond to actual practice. Those upon the second would take into account both pecuniary and hygienic economy. Those of the third would consider only what was intrinsically most fitting.

The current standards for daily dietaries for men and daily rations for domestic animals have been based mainly upon the considerations in the first class. In the feeding of domestic animals and in the nutrition of people who are limited in respect to either the supply of food to which they have access or their means for purchasing their food the data of the second class would be appropriate. But for people in moderate and comfortable circumstances in most parts of Europe and the United States, where commerce brings a large variety of food materials to every market and incomes are large enough to warrant use of properly selected food, data of the third class are the ones to be taken into consideration.

EUROPEAN AND AMERICAN DIETARIES AND STANDARDS.

The pages which precede have outlined, though very incompletely, the data now available regarding the actual food consumption, and have indicated in a general way those which have been thus far obtained by experimental inquiry regarding the physiological demand. I hope, in a future publication, to discuss this subject more fully and to indicate what appear to be the inferences to be derived from the knowledge now at our disposal and what are the lines of inquiry which are needed to make that knowledge more nearly adequate.

Meanwhile, I venture to quote the following from a previous article upon the subject.¹

It will be observed that this discussion is based upon the assumption that the body requires for its nourishment—

(1) Enough of protein to make up for the protein and muscle and other nitrogenous substances consumed in the body.

(2) Enough energy to supply the demand for heat and muscular work. The estimates for energy are based upon Rubner's factors (4.1 calories for each gram of protein, the same for each gram of carbohydrates,

¹Report of Storrs (Conn.) Experiment Station for 1891, pp. 145-149.

and 9.3 for each gram of fats). It is further assumed that in serving as fuel the fats and carbohydrates may replace one another in proportion to their potential energy, so that it is not necessary to lay down specific quantities of either, provided the sum of the two is sufficient for the purpose. The fitting of the food to the demands of the palate and the digestive apparatus are, of course, factors of the utmost importance, but can not be discussed here.

European dietary standards.—The standards in Table 38, compiled from European sources, are intended to represent roughly the needs of average individuals of the classes named in England and Germany. Nos. 1 to 8 are based upon observations of Voit and his followers. For Nos. 1 and 3 the results of numerous estimates by Dr. Camerer of the food of his own children, and by Voit and Forster of the food consumed by a number of other children, are used. No. 2 was calculated by myself from the data of Nos. 1 and 3. The figures given represent means between smaller quantities for the younger and larger for the older children. The data collated in Table 37 above seem to call for a revision of the standard for children as well as those for adults. Nos. 5 and 6 are based upon observations chiefly by Forster. Nos. 7 and 8 are by Voit, and based both upon quantities consumed by individuals under experiment, and upon observed dietaries of a much larger number of persons in Germany. No. 7 is the one so frequently quoted as Voit's standard for a "mittlerer Arbeiter," a laboring man at moderate work.¹ These figures represent the average needs of ordinary mechanics and laboring men at their ordinary work, as estimated from the food consumed by such men in Germany and especially in the region of Munich. For men not engaged in muscular labor Voit regards it as better to use less carbohydrates, not over 350 grams per day, and supply the remaining need with fat. In other words, the food of well-to-do people, with intellectual rather than muscular labor, may advantageously contain more meat, butter, and other animal foods rich in fat, than the largely vegetable food of the German working people supplies. Voit would have somewhat over half of the 118 grams of protein of the food of the average laboring man at moderate work supplied by meat and other animal foods.

It will be borne in mind that these quantities, like those in the tables of this article, generally refer to the total rather than the digestible nutrients of the food. Such dietaries as Voit proposes would contain approximately the following amounts of digestible nutrients:

	Protein.	Fats.	Carbo- hydrates.
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
For laboring man at moderate work	116	53	450
For laboring man at hard work	130	95	402

No. 9 is by Moleschott, whose earlier scientific life was spent in Germany, but who has lived for many years in Italy. It may therefore be called either Italian or German. No. 10 is German. Nos. 11 to 15 are dietaries estimated by Playfair, an Englishman, from the data cited in Table 37 and others.² The figures for No. 11, subsistence diet, are based upon dietaries of convalescents in hospitals, of people in prison, and of laboring people in England, and in the so-called "cotton famine" of 1862-63. For No. 12, diet in quietude, the dietaries of soldiers in time of peace, and for No. 13, diet of adult in full health, army dietaries (English and continental) in war were employed. The estimates for active laborers, No. 14, were based upon

¹ Physiologie des Stoffwechsels und der Ernährung, 519-523.

² Chem. News, XI, 1865, 222.

observations of the food of men at moderately active work, who would correspond in demand for nutrients to the "mittlerer Arbeiter" for which the dietaries of Voit, Moleschott, and Wolff, Nos. 7, 9, and 10, were calculated. The figures of No. 15 were based upon observations of food of men in England at harder work, such as those of Nos. 7, 8, and 9 of Table 38.

TABLE 38.—*European standards for daily dietaries for people of different classes.*

Reference No.		Nutrients.				Potential energy.
		Protein.	Fats.	Carbo-hydrates.	Total.	
	Children:	Grams.	Grams.	Grams.	Grams.	Calories.
1	1 to 2 years, average	28	37	75	140	765
2	2 to 6 years, average	55	40	200	295	1,420
3	6 to 15 years, average	75	43	325	443	2,040
4	Aged woman	80	50	260	390	1,860
5	Aged man	100	68	350	518	2,475
6	Woman at moderate work	92	44	400	536	2,425
7	Man at moderate work (Voit)	118	56	500	674	3,055
8	Man at hard work (Voit)	145	100	450	695	3,370
9	Man at moderate work (Moleschott)	130	40	550	720	3,160
10	Man at moderate work (Wolff)	125	35	540	700	3,030
11	Subsistence diet (Playfair)	57	14	341	412	1,760
12	Diet in quietude (Playfair)	71	28	341	440	1,950
13	Adult in full health (Playfair)	119	51	531	701	3,140
14	Active laborers (Playfair)	156	71	568	795	3,630
15	Hard-worked laborers (Playfair)	185	71	568	824	3,750

It is hardly necessary to explain that the standards of this table represent only general averages. Thus Voit, Playfair, and the other physiologists named assume that for an ordinary laboring man, doing an ordinary amount of work, the amounts of nutrients stated in Nos. 7, 9, 10, and 14 will suffice; that with them he will hold his own, and that any considerable excess above these quantities will be superfluous. No one expects any given man to adjust his diet exactly to either of these standards. He may need more, and may perhaps get on with less. He may eat more fats and less carbohydrates, or he may consume more protein, if he is willing to pay for it. If, however, he has much less protein and keeps up his muscular exertion, he will be apt, sooner or later, to suffer.

Of course, different individuals, under like conditions, will both require and consume different quantities of nutrients. In general, the larger the person, that is to say the bulkier the machinery in his organism, the more of protein and other nutrients will be consumed. Hence, men need, on the average, more than women and children. The requirements vary with the muscular activity. A man at hard work requires more nutrients than one at lighter work or at rest. Aged people, who are generally less active than those in the prime of life, require less food.

The four dietaries by Voit, Moleschott, Wolff, and Playfair, just mentioned (Nos. 7, 9, 11, and 14), have long been accepted by physiologists and chemists as expressing about the average quantities of nutrients which a man doing moderately hard, muscular work would need in his food each day. They vary considerably from each other, however. That of Moleschott, for instance, calls for 130 grams of protein; that of Voit, only 118. There are similar differences in the quantities of fat and carbohydrates. But no one adjusts his food exactly to chemical standards. Different people consume very different foods, and yet they get on very well, and it is perfectly clear that either of these standards may be right enough. And different as they are, a remarkable agreement between them has lately come to light.

When these standards were proposed experimental science had not taught how to measure the fuel value of food by the potential energy of its constituents. Late research has told how this may be done. The energy is measured in heat units, for which calories are here used. A gram of protein or of carbohydrates is assumed to contain 4.1 and a gram of fats 9.3 calories. Applying this measure to these dietaries, the extreme variation in the four is only from 3,032 to 3,160 calories. That is to say,

four of the most prominent investigators, Playfair in England, and the others in Germany and Italy, working with different people and by more or less different methods, arrived at estimates which vary somewhat in the proportions of the nutrients, but when the different standards are reduced to terms of potential energy they agree almost exactly. The closer scientific scrutiny, which the latest and most painstaking research has made practicable, serves only to bring the apparent discrepancies into accord and thus confirm, in an unexpected and most striking way, the correctness of the standards.

To doubt the conclusions of such eminent authorities, when these conclusions are based upon such diversified experience and experiment and are substantiated in so striking a way as that just described, may seem presumptuous. I venture, nevertheless, to urge that these standards do not represent the quantities of nutritive material that the average mechanic or other workingman needs in order to do a fair day's work; that the allowance is too small for what such a man ought to do and can well do. The reasons for this view are found in the teachings of later experimental research, especially that of Voit, and others who have been associated with him, regarding the functions of food and its nutritive ingredients, and in the studies of American dietaries above described and the inferences which they seem to warrant. The kernel of the whole question is found in the fact that the European standards are based upon the food consumption of people whose plane of living is low in comparison with that of the people in the United States. The thesis which I attempt to defend is that to make the most out of a man, to bring him up to the desirable level of productive capacity, to enable him to live as a man ought to live, he must be better fed than he would be by these standards. This is only part of the story, but it is an essential part. The principle is one that reaches very deep into the philosophy of human living.

American v. European standards.—In the passage just quoted emphasis is laid upon the fact that the current European dietary standards are based mainly upon the facts of actual food consumption. Thus, Voit's standard for a laboring man at moderate work is based chiefly upon his observations of the quantities of food actually consumed by manual laborers, mostly mechanics, in Munich and other places in Bavaria, who were reasonably well paid and reasonably well fed, as judged by the standards of wages and living which obtained in these places at the times when the observations were made, twenty years or more ago. In the same way Playfair's estimates were based chiefly upon the conditions which he observed in England some thirty years ago. If either one had used such data as he would find in New England to-day he doubtless would have made his dietary standards correspond. The most cursory examination of Table 37 shows that the American standard in this respect would be much higher than the European. My own belief is that the American standard is a much more desirable one. The scale of living or "standard of life" here is much higher than it is in Europe. People in Massachusetts and Connecticut are better housed, better clothed, and better fed than in Bavaria or Prussia, they do more work, and they earn higher wages. While the statistics are not as full as is to be desired, there appears to be a consensus of those who have observed most closely that the facts lie in this direction. Very likely what Voit reckons as hard or severe muscular work would count here as only moderate work.

Considering the body as a machine, the American workingman has a more strongly-built machine and more fuel to run it than has his European brother. While it is not absolutely proven, it seems in the highest degree probable that the higher standard of living, the better nutrition, the larger product of labor and the higher wages go together. It is in view of such considerations as these that I have ventured to suggest more liberal standards for dietaries than those which have been proposed by the European authorities above quoted. The following standards are from the article above referred to:¹

SUGGESTIONS FOR DIETARY STANDARDS.

In Table 39, I venture to suggest certain proportions of protein and energy which may be appropriate as averages for dietaries for people of different forms of activity. In the method by which the estimates are made, these agree with those of Voit and Playfair in that the proportions assumed to be needed are inferred empirically from those consumed in observed cases. They differ from the ones referred to in the use of the experience that has accumulated during the not far from two decades since the latest of the latter, those of Voit, were proposed; a period of no little activity of research in the science of nutrition. But the principal reason for the wide differences in the quantities is that the results of the inquiries regarding American dietaries have been taken into account in the estimates here given.

Concerning the quantities of protein, it must be confessed that the experimental data do not yet suffice for at all exact estimates even for average persons of different classes. The proportions here given are such as seem to me reasonable in the light of the present knowledge. The same may be said regarding the figures for energy.

The estimates in Table 39 are expressed simply in terms of protein and energy. There is really little ground for giving quantities of fats and carbohydrates in such standards, since the two are mutually replaceable, and the quantities must vary with the conditions of consumption.

Regarding the standards of Table 38, a few additional remarks will suffice.

It will be observed that the quantities are in a well-nigh regularly ascending scale. The lowest are such as have been found to suffice amply for men of sedentary life. The highest accord with the larger, but not the largest, of the American dietaries quoted above. The quantities in No. 1 are about the same as were found ample for the German professors and lawyers above referred to, who were men of decided mental activity. They might be small for the average man of like occupation with us, in which case such proportions as those of No. 2 would be more appropriate. The standard for a man at moderate work, which Voit places at 118 grams of protein and 3,050 calories, and

¹ Report of Storrs (Conn.) Experiment Station, 1891, p. 160.

Playfair and other authorities at very nearly the same figures, I have placed at 125 grams of protein and 3,500 of energy. These are smaller than the averages of the American dietaries, but I have assumed that the waste in the latter would count for considerable and that the quantities actually eaten would not be so very far above these figures, particularly as the allowance here for a man at active muscular work is 150 grams of protein and 4,000 calories of energy.

It has been assumed a woman requires on the average eight-tenths as much as a man for corresponding muscular activity. I have assigned the dietary of a man with light exercise to a woman at moderate work, and that of a man with very little physical exercise to a woman at light work, thus providing for a woman rather more than eight-tenths as much as a man. Very likely eight-tenths would accord more nearly with the actual needs.

It is quite possible that the quantities of nonnitrogenous nutrients necessary to furnish the energy called for in the following standards would be large in comparison with the amounts of protein; in other words, that the nutritive ratios are too wide for normal nutrition. In this respect they are a compromise between the currently accepted European standards and the actual dietaries observed in New England.

TABLE 39.—*Standards for daily dietaries (American).*

	Protein.	Fuel value.	Nutritive ratio.
	<i>Grams.</i>	<i>Calories.</i>	<i>1:</i>
Woman with light muscular exercise	90	2,400	5.5
Woman with moderate muscular work	100	2,700	5.6
Man without muscular work			
Man with light muscular work	112	3,000	5.5
Man with moderate muscular work	125	3,500	5.8
Man with hard muscular work	150	4,500	6.3

CHAPTER XI.

ERRORS IN OUR FOOD ECONOMY.¹

Fortunately, enough information has already been gained to indicate in a general way what are the principal mistakes in the food economy of people in the United States, even though we are not yet certain as to all the details.

Scientific research, interpreting the observations of practical life, implies that several errors are common in the use of food:

First, many people purchase needlessly expensive kinds of food, doing this under the false impression that there is some peculiar virtue in the costlier materials, and that economy in our diet is somehow detrimental to our dignity or our welfare. And, unfortunately, those who are most extravagant in this respect are often the ones who can least afford it.

Secondly, the food which we eat does not always contain the proper proportions of the different kinds of nutritive ingredients. We consume relatively too much of the fuel ingredients of food, such as the fats of meat and butter, the starch which makes up the larger part of the nutritive material of flour and potatoes, and sugar and sweet-meats. Conversely, we have relatively too little of the protein of flesh-forming substances, like the lean of meat and fish and the gluten of wheat, which make muscle and sinew and which are the basis of blood, bone, and brain.

Thirdly, many people, not only the well-to-do, but those in moderate circumstances, use needless quantities of food. Part of the excess, however, is simply thrown away with the wastes of the table and the kitchen; so that the injury to health, great as it may be, is doubtless much less than if all were eaten. Probably the worst sufferers from this evil are well-to-do people of sedentary occupations—brain workers as distinguished from hand workers.

Finally, we are guilty of serious errors in our cooking. We waste a great deal of fuel in the preparation of our food, and even then a great deal of the food is very badly cooked. A reform in these methods of cooking is one of the economic demands of our time.

¹The statements in this chapter are taken mainly from articles by the author in the *Century Magazine*, *The Forum*, and the Report of the Storrs (Conn.) Experiment Station for 1892.

CHEAP V. DEAR FOOD.

We can not judge of the nutritive value of food by the quantity. This fact is brought out clearly by the figures in Table 16 on page 139. There is as much nutriment in a pound of wheat flour as in $3\frac{1}{2}$ quarts of oysters, which weigh 7 pounds. There is still less connection between nutritive value and price. In buying at ordinary market rates we get as much material to build up our bodies, repair their wastes, and give strength for work, in 5 cents' worth of flour or beans or codfish, as 50 cents or \$1 will pay for in tenderloin, salmon, or lobsters.

Round steak at 15 cents a pound is just as digestible and is fully as nutritious as tenderloin at 50. Mackerel has as high nutritive value as salmon, and costs from an eighth to half as much. Oysters are a delicacy. If one can afford them there is no reason for not having them, but 25 cents invested in a pint would bring only about an ounce of protein and 230 calories of energy. The same 25 cents spent for flour at \$6 a barrel, or 3 cents a pound, would pay for nine-tenths of a pound of protein and 13,700 calories of energy. When a day-laborer buys bread at $7\frac{1}{2}$ cents a pound the actually nutritive material costs him three times as much as it does his employer, who buys it in flour at \$6 a barrel.

FOOD OF THE POOR.

Illustrations of the prejudice of people, especially those in moderate circumstances, against the less expensive kinds of food are very common.

Mr. Lee Meriwether, who has given much attention to this special subject, cites a case in point, that of a coal laborer who boasted: "No one can say that I do not give my family the best of flour, the finest of sugar, the very best quality of meat." He paid \$156 a year for the nicest cuts of meat, which his wife had to cook before 6 in the morning or after half past 6 at night, because she worked all day in a factory. When excellent butter was selling at 25 cents a pound he paid 29 cents for an extra quality. He spent only \$108 a year for clothing for his family of 9, and only \$72 a year for rent in a close tenement house, where they slept in rooms without windows or closets. He indulged in this extravagance in diet when much less expensive food materials, such as regularly come upon the tables of men of wealth, would have been just as nutritious, just as wholesome, and in every way just as good, save in the gratification to pride and palate. He was committing an immense economic blunder. Like thousands of others, he did so in the belief that it was wise and economical.

The sad side of the story is that the poor are the ones who practice the worst economy in the purchase as well as the use of food. The Massachusetts Bureau of Labor, in collecting the dietaries above referred to, made numerous inquiries of tradesmen regarding the food of the poor in Boston, meaning by poor "those who earn just enough to keep themselves and families from want." The almost universal testimony was, "They usually want the best and pay for it, and the

most fastidious are those who can least afford it." The costliest kind of meat, the finest flour, and very highest priced butter were demanded, and many scorned the less expensive meats and groceries such as well-to-do and sensible people were in the habit of buying.

I have taken occasion to verify these observations by personal inquiry in Boston markets. One intelligent meat man gave his experience with a poor seamstress, who insisted on buying tenderloin steak at 60 cents per pound. He tried to persuade her that other parts of the meat were just as nutritive, as they really are, but she would not believe him; and when he urged the wiser economy of using them she became angry at him for what she regarded as a reflection upon her dignity. "My wealthy customers," said he, "take our cheaper cuts, but I have got through trying to sell these economical meats to that woman and others of her class."

I am told that people in the poorer parts of New York City buy the highest priced groceries, and that the meat men say they can sell the coarser cuts of meat to the rich, but that people of moderate means refuse them. I hear the same thing in Washington and other cities.

ONE-SIDEDNESS OF OUR DIETARY.

I have said that our diet is one-sided, that the food which we actually eat has relatively too little protein and too much fat, starch, and sugar. In other words, it is relatively deficient in the materials which make muscle and bone and contains a relative excess of the fuel ingredients. This is due partly to our large consumption of sugar and partly to our use of such large quantities of fat meats. In the statistics of dietaries above referred to the quantities of fat in the European dietaries range from 1 to 5 ounces per day, while in the American the range is from 4 to 16 ounces. In the daily food of well-to-do professional men in Germany, who were amply nourished, the quantity of fat is from 3 to $4\frac{1}{2}$ ounces per day, while in the dietaries of Americans in similar conditions of life it ranges from 5 to $7\frac{1}{2}$ ounces in the food purchased. The quantities of carbohydrates in the European dietaries range from 9 to 24 ounces, while in the corresponding American dietaries the carbohydrates were from 24 to 60 ounces.

It is customary to estimate the proportion of fuel ingredients to protein in what is called the nutritive ratio. In this estimate 1 part, by weight, of fats is counted as equivalent to $2\frac{1}{4}$ of carbohydrates. Adding the two together gives the amount of the fuel ingredients. In the American dietaries the proportion of fuel ingredients to 1 part of protein ranges from 6.6 to 8.7, and even higher. In the European dietaries of well-nourished people and in the dietary standards which express the average needs according to the teachings of the best physiological observations it is from 4.1 to 6, or thereabout. The rejection of so much of the fat of meat at the market and on our plates at the table is not mere willful wastefulness, it is in obedience to nature's protest against a one-sided and excessive diet.

OVEREATING—INJURY TO HEALTH.

But the most remarkable thing about our food consumption is the quantity. The American dietaries examined in the inquiry mentioned above were of people living at the time in Massachusetts and Connecticut, though many came from other parts of the country. It would be wrong to take their eating habits as an exact measure of those of people throughout the United States. For that matter, a great deal of careful observation will be needed to show precisely what and how much is used by persons of different classes in different regions. Just this kind of study in different parts of the country is greatly needed. But such facts as I have been able to gather seem to imply that the figures obtained indicate in a general way the character of our food consumption. Of the over 50 dietaries of reasonably well-to-do people thus far examined the smallest is that of a mechanic's family. In this the potential energy per man per day was about 3,000 calories. The next smallest was that of the family of a chemist who had been studying the subject and had learned something of the excessive amounts of food which many people with light muscular labor consume. This dietary supplied 3,200 calories of energy per man a day. The largest was that of brickmakers at very severe work in Massachusetts. They lived in a boarding house managed by their employers, who had evidently found that men at hard muscular work out of doors needed ample nourishment to do the largest amount of work. The food supplied 8,850 calories per day.

Voit's standard for a laboring man at moderate work, which is based upon the observation of the food of wage workers who are counted in Germany as well paid and well fed, allows 118 grams of protein and 3,055 calories of energy. The standards proposed by myself in which the studies of American dietaries have been taken into account allow 125 grams of protein and 3,500 calories of energy for a man at moderately hard muscular work. The dietaries of Massachusetts and Connecticut factory operatives, day laborers, and mechanics at moderate work averaged about 125 grams of protein and 4,500 calories of energy. For a man at "severe" work, Voit's standard calls for 145 grams of protein and 3,370 calories of energy. The Massachusetts and Connecticut mechanics at "hard" and "severe" work had from 180 to 520 grams of protein and from 5,000 to 7,800 calories of potential energy, and in one case it rose to the 8,500 just quoted. In the dietary standards proposed by myself it did not seem to me permissible to assign less than 4,000 calories to that for a working man at "hard," and 5,700 for a man at "severe" work.

Just what compounds in food are required for the nutriment of the brain, physiological chemistry has not yet told us; but it is certain that people with little muscular exercise require less food than those at hard muscular labor. Many men whose work and strain are mental

rather than physical suffer from overeating. In a number of dietaries of professional men in Germany, Denmark, and Sweden, including a university professor, a lawyer, physicians, and students, all of whom were in comfortable circumstances, in good health, and amply nourished, the energy varied from 2,180 to 3,035 calories; the mean was about 2,600 calories. The average of the dietaries of professional men and students from the Northern and Eastern States, residing in Middletown, Conn., was 4,155 calories. The range was from 3,205 in the family of the chemist to whom I have referred, to 5,345 in a students' boarding club. These figures, like the others of the American dietaries cited, refer to the food purchased. The average of the food eaten was 3,705 calories. In the students' dietary the food eaten supplied 4,825 calories.

Now it is not easy to see why these men required so much more than was sufficient to nourish abundantly men of like occupation, but unlike temptation to overeating, in Europe. Difference in climate can not account for it. We are a little more given to muscular exercise here, which is very well for us, but it cannot justify our eating so much. In the German army, where especial attention is given to diet, and it has been an axiom since the time of Frederick the Great, that soldiers to march well and fight well must be well fed, a ration for time of peace has been computed at 2,800, and one for time of war at 3,095 calories. During the last Franco-German war, shortly before the battle of Sedan, an order was issued by King, afterwards Emperor, William, which provided an extraordinary war ration, which is estimated at 3,985 calories. If a man with a tremendous physical and nervous tension, required in such terrible service as the German soldier was called upon to render in his victorious contests with the Frenchman, is well supplied by a ration of less than 4,000 calories of energy, and German professional men in their quiet but active and successful intellectual work at home are amply nourished with 2,700 calories and less, how happens it that men of mental rather than muscular occupation here consume food with 4,000 calories and more?

I think the answer to this question is found in the conditions in which we live. Food is plenty. Holding to a tradition which had its origin where food was less abundant, that the natural instinct is the measure of what we should eat, we follow the dictates of the palate. Living in the midst of abundance, our diet has not been regulated by the restraints which obtain with the great majority of the people of the Old World, where food is dear and incomes are small.

Indeed, the very progress which we are making in our civilization brings with it increased temptation to overeating. The four quarters of the earth are ransacked to supply us with the things which will most tempt our appetites, and the utmost effort of cooks and housewives is used in the same direction. It is all the more fitting, therefore, that information as to our excesses and the ways of avoiding them should come at the same time.

How much harm is done to health by our one-sided and excessive diet no one can say. Physicians tell us that it is very great. Of the vice of overeating, Sir Henry Thompson, a noted English physician and authority on this subject, says:

I have come to the conclusion that more than half the disease which embitters the middle and latter part of life is due to avoidable errors in diet, * * * and that more mischief in the form of actual disease, of impaired vigor, and of shortened life accrues to civilized man * * * in England and throughout central Europe from erroneous habits of eating than from the habitual use of alcoholic drink, considerable as I know that evil to be.

This is in the fullest accord with the opinions of physicians and hygienists who have given the most attention to the subject, and these opinions are exactly parallel with the statistics here cited.

WASTE OF FOOD IN AMERICAN HOUSEHOLDS.

The direct waste of food occurs in two ways, in eating more than is needed and in throwing away valuable material in the form of kitchen and table refuse. That which is thrown away does no harm to health, and in so far as part of it may be fed to animals or otherwise utilized, it is not an absolute loss. That which we consume in excess of our need or nourishment is worse than wasted because of the injury it does to health. A few instances taken from the investigations mentioned above will help to illustrate the waste of food.

One of the dietaries examined by the Massachusetts Labor Bureau was that of a machinist in Boston who earned \$3.25 per day. In food purchased the dietary furnished 182 grams of protein and 5,640 calories of energy per man per day, at a cost of 47 cents. One-half the meats, fish, lard, milk, butter, cheese, eggs, sugar, and molasses would have been represented by 57 grams of protein, 1,650 calories, and 19 cents. If these had been subtracted the record would have stood at 125 grams, 3,990 calories, and 28 cents. This family might have dispensed with one-half of all their meats, fish, eggs, dairy products, and sugar, saved 40 per cent of the whole cost of their food, and still have had all the protein and much more energy than is called for by a standard which is supposed to be decidedly liberal.

In the instance just cited no attempt was made to learn how much of the food purchased was actually consumed and how much was rejected. In some of the dietaries published by the Massachusetts bureau such estimates were made. That of a student's club in a New England college will serve as an example.

The young men of the club, some 25 in number, were mostly from the Northern and Eastern States, and, coming from the class of families whose sons go to college, it seems fair to assume that their habits of eating formed at home would not differ materially from those of the more intelligent classes of people in that part of the country. While the diet of the club was substantial and wholesome, it was plain, as was, indeed, necessary, because several of the members were dependent upon

their own exertions and the majority had rather limited means. Though fond of athletic sports, they could hardly be credited with as much muscular exercise as the average "laboring man at moderate work." The matron, a very intelligent, capable New England woman, had been selected because of her especial fitness for the care of such an establishment. The steward who purchased the food was a member of the club, and had been chosen as a man of business capacity. He thought that very little of the food was left unconsumed. "All of the meat and other available food that was not actually served to the men at the table," said he, "was carefully saved and made over into croquettes. Men who work their way through college can not afford to throw away their food." But actual examination showed the waste to be considerable. The estimates of the quantities of nutrients were based upon the quantities of food materials for a term of three months and upon the table and kitchen refuse for a week. The results were as follows: In food purchased, protein, 161 grams; energy, 5,345 calories. In waste, protein, 23 grams; energy, 520 calories. In food consumed, protein, 138 grams; energy, 4,825 calories. One eighth of the protein and one-tenth of the energy were simply thrown away.

During the succeeding term a second examination of the dietary of the same club was made. Another steward was then in charge. He had learned of the excessive amounts of food in the former dietary, and planned to reduce the quantities. This was done largely by diminishing the meats. He stated that he did not apprise the club of the change, and that it was not noticed. As he put it, "The boys had all they wanted, and were just as well pleased as if they had had more." Estimates as before, but with more care in determining the waste, showed in food purchased, protein 115 grams; energy, 3,875 calories. In waste, protein, 11 grams; energy, 460 calories. In food consumed, protein, 104 grams; energy, 3,415 calories. One-tenth of the nutritive material of the food this time was thrown away. The young men were amply nourished with three-fifths of the nutrients they had purchased in the previous term.

How much food is required on the average by men whose labor is mainly intellectual is a question to which physiology has not yet given a definite answer, but it is safe to say that the general teaching of the specialists who have given the most attention to the subject would call for little more than the 104 grams of protein and very much less than the 3,400 calories of energy in the food estimated to be actually consumed by these young men when the second examination was made. They could have dispensed with half of all the meats, fish, oysters, eggs, milk, butter, cheese, and sugar purchased for the first dietary and still have had more nutritive material than they consumed in the second. Not only was one-tenth or more of the nutrients thrown away in each of the two cases, but what makes the case still worse peculiarly, the rejected material was very largely from the animal foods in which it is the most expensive.

The estimates of the quantities of food in the two dietaries just quoted were made from tradesmen's bills and the composition was calculated from analyses of similar materials rather than of those actually used. The figures are therefore less reliable than if the food and wastes had been actually weighed and analyzed. In some dietaries lately examined in Middletown, Conn., all the food has been carefully weighed and portions have been analyzed, and the same has been done with the table and kitchen refuse. The results therefore show exactly how much was purchased, consumed, and thrown away. One dietary so investigated was that of a boarding house. The boarders were largely mechanics of superior intelligence and skill, and earning good wages; the mistress was counted an excellent housekeeper and the boarding house a very good one. About one-ninth of the total nutritive ingredients of the food was left in the kitchen and table refuse. The actual waste was worse than this proportion would imply, because it consisted mostly of the protein and fats, which are more costly than the carbohydrates. The waste contained nearly one-fifth of the total protein and fat, and only one-twentieth of the total carbohydrates of the food. Or, to put it in another way, the food purchased contained about 23 per cent more protein, 24 per cent more fats, and 6 per cent more carbohydrates than were eaten. And, worst of all for the pecuniary economy, or lack of economy, the wasted protein and fats were mostly from the meats which supply them in the costliest form.

In another dietary, that of a carpenter's family, also in Middletown, Conn., 7.6 per cent of the total food purchased was left in the kitchen and table wastes. The total waste was somewhat worse than this proportion would imply, because it consisted mostly of the protein and fats, which are more costly than the carbohydrates. The waste contained about one-tenth of the total protein and fat, and only one twenty-fifth of the total carbohydrates of the food; or, to put it in another way, the food purchased contained nearly 10 per cent more protein, 12 per cent more fat, and 5 per cent more carbohydrates than were eaten; and here again the wasted protein and fats were mostly from the meats, which supplied them in the costliest form. At the rate in which the nutrients were actually eaten in this dietary, the protein and fats in the waste would have each supplied one man for a week, and the carbohydrates for three days.

These cases are probably exceptional; at least it is to be hoped that they are. Among 8 dietaries lately studied in Middletown those above named showed the largest proportion of material thrown away. In the rest it was much less. In two cases there was almost none. It is worth noting, however, that the people in these two had the largest incomes of all. In other words, the best-to-do families were the least wasteful.

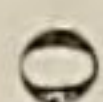
This form of bad economy is not confined to the kitchen, but begins in the market. In buying meat in the retail markets it is a common practice to have the bone and considerable of the fat cut out and left.

In thus removing the "trimmings" the butcher is apt to cut out considerable else than the bone and fat. In a piece of roast beef weighing 16 pounds, the "trimmings," which consisted of the bone and the meat cut out with it, and which were left for the butcher to sell to the soap man, or get rid of as he might otherwise choose, weighed $4\frac{1}{2}$ pounds. The butcher said that he sold this sort of beef largely to the ordinary people of the city—mechanics, small tradesmen, and laborers.

The $4\frac{1}{2}$ pounds of "trimmings" consisted of, approximately, $2\frac{1}{4}$ pounds of bone and one-half pound of tendon ("gristle"), which would make a most palatable and nutritious soup, and $1\frac{3}{4}$ pounds of meat, of which 1 pound was lean and three-fourths pound fat. It is estimated that the nutritive materials of meat thus left unused, saying nothing of the bone and tendon, contained some 15 per cent of the protein and 10 per cent of the potential energy of the whole. The price of the beef was \$2.24. Assuming the nutritive value of the ingredients of the "trimmings" to be $12\frac{1}{2}$ per cent of the whole, 28 cents worth of the nutritive material, besides the bone and tendon, was left at the butcher's.

Dr. S. A. Lattimore, professor of chemistry in the University of Rochester, N. Y., tells me that while a member of the board of health of that city he directed the officer in charge of the collection of garbage to note the character of the waste material. It was ascertained that from the streets inhabited by the well-to-do classes, where the culinary affairs were largely left to the servants, the amount of waste thus collected was enormous, and that a considerable proportion of the food purchased was literally thrown away by careless servants. A surprisingly large amount of this waste consisted of good bread. Among the people in moderate circumstances this waste was less.

The common saying that "the average American family wastes as much food as a French family would live upon" is a great exaggeration, but the statistics cited show that there is a great deal of truth in it. Even in some of the most economical families the amount of food wasted, if it could be collected for a month or a year, would prove to be very large, and in many cases the amounts would be little less than enormous.





Bulletin

Bd.: 16/21. 1893/95

Washington, DC 1895

Oecon. 362 gh-16/21

urn:nbn:de:bvb:12-bsb11660546-1